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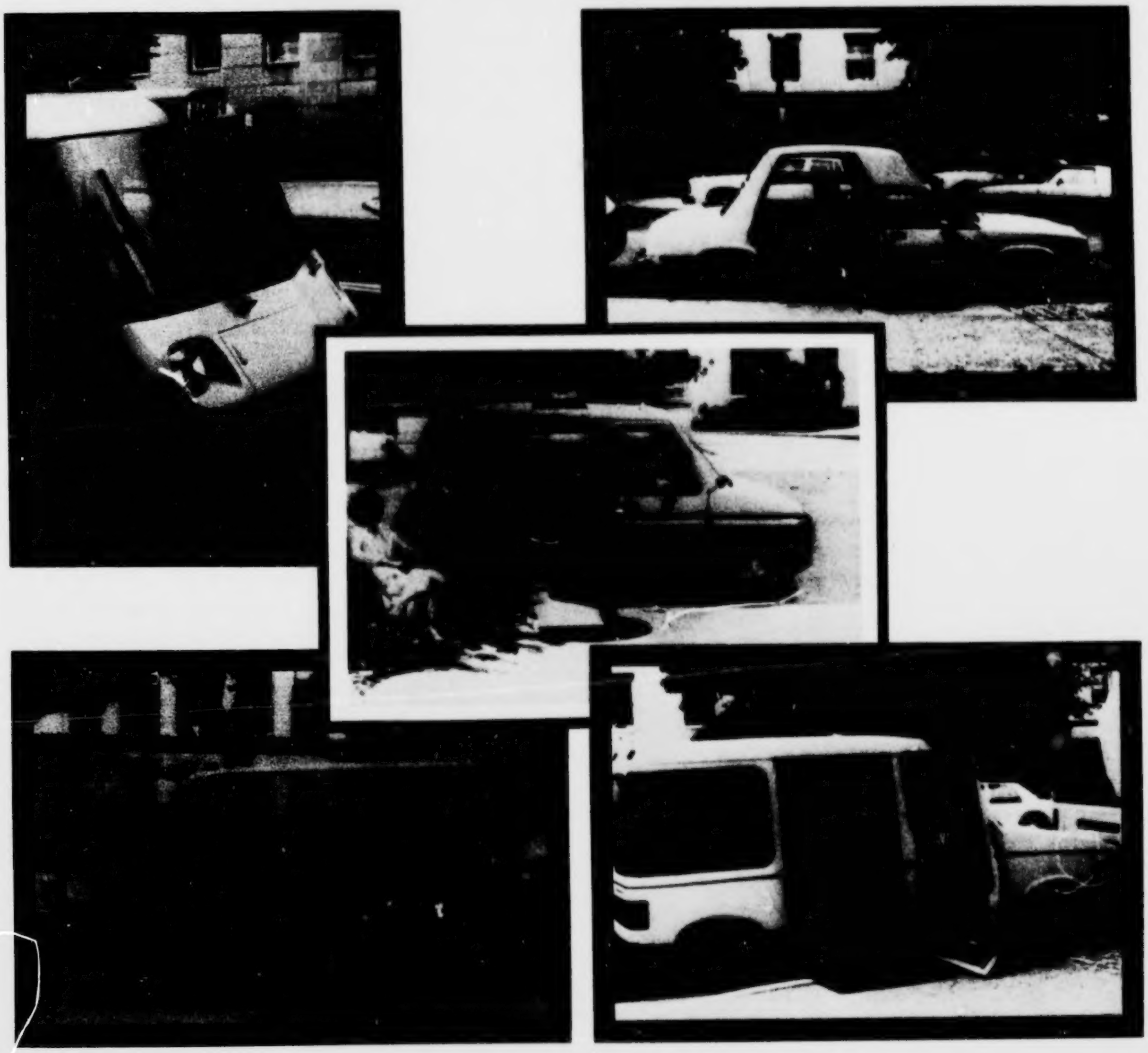
PARATRANSIT VEHICLE TECHNOLOGY:

GUIDELINES FOR REGULATORS, OPERATORS AND DEVELOPERS



PREPARED FOR
TRANSPORTATION DEVELOPMENT CENTRE

BY

DeLCan

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PARATRANSIT VEHICLE TECHNOLOGY:

GUIDELINES FOR REGULATORS,

OPERATORS AND VEHICLE DEVELOPERS

by

DeLCan

May, 1982

The contents of this report reflect the views of the contractor and not necessarily the official views or policies of the Transportation Development Centre, Transport Canada.

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Mr. John Pearson; Roads and Transportation Association of Canada

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17. Abstract

The objective of the report is to provide those concerned with the design, regulation or operation of paratransit services with guidelines to enable them to more effectively provide an efficient vehicle or system.

Paratransit has been described as a bridge between the conventional auto and conventional transit and includes such operating modes as hire and drive services, hail or phone services and pre-arranged ride sharing services. Vehicles currently in use for paratransit services include passenger cars, special taxi vehicles, standard and modified multipurpose vehicles (vans) and small buses.

Two principal services offered by paratransit and addressed in this study are:

(1) a high-quality alternative to the automobile through trip-sharing;

(2) mobility for the elderly or handicapped, with particular emphasis being placed on the latter.

The study is presented in four sections, including: assessment of currently available vehicles; legislation affecting design and service of vehicles; acceptable and desirable vehicle specifications based on user and operator requirements; and guidelines itemizing areas of concern as an aid to ensure establishment of viable taxi/paratransit operations.

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17. Résumé

Le rapport vise à offrir aux parties impliquées dans la conception, la réglementation ou l'exploitation de services non conventionnels de transport collectif une aide technique pouvant servir à améliorer les véhicules ou les systèmes.

Les transports collectifs non conventionnels incluent toute une gamme de modes allant de l'auto conventionnelle jusqu'au transport collectif conventionnel. Ils incluent aussi plusieurs types de services tels que les services de location, les services hélés ou réservés par téléphone et les services de covoiturage conclus à l'avance. Les véhicules utilisés présentement pour ces types de services incluent les voitures particulières, les véhicules taxi spéciaux, les camionnettes avec ou sans modifications et les minibus.

Deux types de services offerts par les transports collectifs non conventionnels et visés par ce rapport sont les suivants: (1) offrir une alternative de haute qualité aux voitures particulières par l'entremise du covoiturage et (2) assurer la mobilité des vieillards et des handicapés; avec emphase particulière sur ce dernier.

Le rapport est présenté en quatre sections comprenant: l'évaluation des véhicules existants, la réglementation touchant à la conception et à l'exploitation des véhicules, les spécifications acceptables et désirables pour les voitures en fonction des exigences des utilisateurs et des exploitants et les normes suggérées d'exploitation afin d'assurer un service viable.

18. Mots-clés
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1.0 INTRODUCTION

1.1 Project Background

The project entitled "Paratransit Vehicle Technology: Guidelines for Regulators, Operators and Vehicle Developers" was initiated by the Transportation Technology Committee of the Roads and Transportation Association of Canda (RTAC). Impetus for the project was provided by the considerable interest generated by the GSM Taxi which was displayed at the RTAC Conference in Toronto in September, 1980.

The Transportation Development Centre of Transport Canada agreed to fund and carry out the study. The Terms of Reference were generated in February, 1981 and requests for proposals issued in March. The project was subsequently awarded to DeLCan (De Leuw Cather, Canada Ltd.).

1.2 Project Objectives

The principal objective of the study is to enable a document to be prepared, for dissemination by RTAC, that will provide those concerned with the design, regulation or operation of paratransit services with guidelines to enable them to more effectively provide for an efficient vehicle or system. It is intended that, by means of these guidelines, a degree of standardization may be attained in the areas of vehicle design and operational structure for taxi and paratransit services.

1.3 Scope of the Study

The word 'paratransit' has been in use for many years although it appears to have become a fashionable term in transportation literature only recently. The term encompasses a wide range of services, and for this reason there are a multitude of interpretations of what is meant by paratransit. Demand responsive transit and private ride sharing are the principal categories of transportation service grouped together to form **'paratransit'**. Although universal agreement on a definition is lacking, essentially the word denotes organized ride sharing activity in the range between (but not including) pickup carpools organized solely at the initiative of their individual members, and fixed route bus service. The system characteristics that unify the services within this wide range are the use of rubber-tired vehicles and the highway system, ride-sharing by unrelated passengers with different origins and/or destinations, flexible routing to serve specific rider requirements rather than travelling only high density corridors, and some measures of formal organization to facilitate the ride-sharing arrangements. The degree of route flexibility may be as complete as that for conventional taxi services or may only involve minor deviations from a fixed bus route, at the request of patrons.

The current interest in paratransit is largely due to the emergence of a new set of values relating to mobility and a new set of economic and environmental realities. Specifically, paratransit is viewed as a potential way of (1) providing a relatively high quality alternative to the automobile which can induce a net savings in vehicle-kilometres of travel (thereby reducing time-related congestion costs, direct costs, energy consumption and travel related-vehicle emissions); and (2) ensuring mobility and access to opportunity for those individuals who are unable (by virtue of age, physical disability or perhaps economic inability) to use a private automobile or conventional transit.

These two goals essentially reflect two distinct orientations toward paratransit. The former view is service oriented, focussing on issues of efficiency and framed by an orientation towards inputs (resources consumed) and outputs (service provided). The latter goal is principally derived from an increasing awareness of social welfare norms and is oriented towards specific market segments.

This project is directly oriented towards a specific market segment - the mobility handicapped. The discussion on paratransit vehicles in development, and the recommended vehicle specifications, is presented with this increasingly apparent sector of society in mind. It is fully acknowledged that taxi and paratransit services are not limited to the mobility disadvantaged and, although this report deals with vehicles capable of carrying wheelchairs, it is realized that able-bodied persons will remain the mainstay of all but the most specialized taxi and paratransit services. This report is thus of greater relevance to those operators willing to provide a service capable of carrying mobility handicapped persons, rather than conventional taxi/paratransit services. It is not, however, intended that the vehicles and vehicle characteristics addressed in the report are to totally replace other conventional vehicles, but rather that they should definitely be an available option in any paratransit service for transportation of elderly and handicapped persons.

1.4 Study Contents

The study is presented in four distinct parts, as follows:

Chapter 2 - Vehicle Assessment
This chapter reviews taxi and paratransit operating modes and discusses the vehicles that are currently available and used as service providers. Some vehicles currently in development are being designed for paratransit use. These vehicles are reviewed with particular attention given to the North American vehicles. The design trends in the standard vehicles are discussed as these vehicles that have been the principal source for taxi and paratransit operators.

Chapter 3 - Legislation
The existing Canadian legislation that affects vehicle design, construction and utilization is identified. A review of 'sample' or

'model' legislation is undertaken and the implications of legislation as it may affect vehicle technology and design are addressed.

Chapter 4 - Vehicle Specifications

Following a review of user requirements and operational requirements the shortcomings of existing/proposed vehicles are addressed. On the basis of user and operator requirements and the state-of-the-art in vehicle technology, specifications are presented for 'Desirable' and 'Acceptable' levels of paratransit vehicle design. This is not to suggest that specifications less stringent than the 'Acceptable' level are unacceptable, but rather that all attempts should be made to meet the 'Acceptable' level. The specifications are presented as a guide to vehicle developers in order that they may benefit from the research undertaken on user and operator requirements rather than attempt to design a new vehicle from the ground up.

Chapter 5 - Guidelines

Vehicle specifications of relevance to the vehicle developers are presented in the previous chapters. This chapter provides guidelines intended for use not only by developers but also regulators and operators of paratransit services. The guidelines are essentially an itemization of areas of concern, to be addressed by the appropriate persons or bodies, to ensure establishment of a viable taxi/paratransit operation. This section is highlighted in the report, being printed on coloured paper.

2.0 VEHICLE ASSESSMENT

2.1 Taxi and Paratransit Operating Modes

Historically taxicabs have provided an exclusive door-to-door transportation service for either single passengers or pre-formed groups. A multitude of regulations, principally designed with regard to safety, service levels and fares, have effectively prohibited operators from providing a service that deviates from the standard door-to-door exclusive trip.

Within the last decade a number of transportation developments have combined to stimulate interest among policy makers and these have resulted in a re-evaluation of the traditional policies regarding taxicabs. One of the major instruments of change has been the increased awareness of the requirements of the transportation disadvantaged, and the ensuing legislative directives requiring that special efforts be made to provide improved transportation services to those unable to use conventional fixed route transit services.

Paratransit has been described as a bridge between the conventional auto and conventional transit. Prior to the growth of paratransit, the only options available for urban transportation were personal automobile, exclusive ride taxi or conventional transit. Of the numerous existing paratransit concepts, some have developed from the automobile end of the spectrum (such as variations of the taxi service, and carpooling), while others have been developed from the other extreme, such as subscription bus services and dial-a-ride.

This section provides data on many of the taxi and paratransit operating modes in use and examples of their implementation.

Paratransit services can be grouped as follows:

(a) hire and drive services

(b) hail or phone services (demand responsive)

(c) pre-arranged ride sharing services

Figure 2.1 provides data on the general service characteristics of a number of paratransit modes. These modes all, as previously mentioned, fall between the conventional auto and transit modes, and are arranged in the order corresponding to their similarity in service characteristics.

The three categories of paratransit service are indicated at the top of the table. There is, however, considerable variation within each of these categories with respect to possible service levels, ownership, operation and regulation. The table serves a purpose in simplistically indicating paratransit general characteristics.

FIGURE 2.1

PARATRANSIT: GENERAL SERVICE CHARACTERISTICS BY MODE

		Para-transit Modes						
		Hire and drive services	Hail or phone services			Prearranged ride-sharing services		
	Private auto	Daily and short-term rental car	Taxi	Dial-a-ride	Jitney	Car pool	Subscription bus	Conve tiona transi
Direct route (DR) or route deviations (RD)?	DR	DR	DR	RD	RD	RD	RD	RD
Door-to-door?	Yes	Maybe	Yes	Yes	No	Yes	Maybe	No
Travel time spent as passenger (P) or driver (D)?	D	D	P	P	P	P/D	P	P
Ride shared (S), or personal (P)?	P	P	P/S	S	S	S	S	S
System routes fixed (F), semi-fixed (S), or variable (V)?	V	V	V	V	S	S	S	F
Access determined by prior arrangement (A), fixed schedule (F), phone (P), street hailing (H), or at user's discretion (U)?	U	U	H/P	P	H	A	A	F
Vehicle parking required (PR) or not (NP)?	PR	PR	NP	NP	NP	PR	PR/NP	NP
Convenient for baggage?	Yes	Yes	Yes	Maybe	Maybe	Maybe	Maybe	No

Source: Reference 1

It should be noted that the same vehicles can provide different services at different times, if the regulatory framework permits. For example, a taxicab can provide regular taxi, dial-a-ride, jitney and subscription services when the regulations include suitable fare and service standards for these different services. Figure 2.2 indicates general markets for paratransit services.

The hire and drive services, generally in the form of short-term or daily car rental, will not be further considered in this report as they are generally not included in the same legislation as other taxi and paratransit modes.

Conventional Taxi: The conventional taxi service is a demand responsive exclusive service. The taxi can be summoned either by telephone or curb hailing, generally only carries one person or a prearranged group, and provides door-to-door service without detour or intermediate stops.

Dial-a-ride Service: This service is a shared ride taxi service summoned by telephone, where new calls may be responded to while the vehicle is in use by other passengers. This service is therefore inferior to a regular taxi service in that it may involve a route deviation and therefore add a time penalty for arrival at the destination. The system offers potential cost savings resulting from increased vehicle occupancy. The dial-a-ride service received close attention in the United States in the 1960's though some taxicab operators had been providing this service for some time. Many experimental dial-a-ride services using small buses and vans were tried out in the 1960's and 1970's. The findings were generally that per-passenger costs were high and demand densities low. The focus of attention changed to the taxicab operators as a potentially more cost-effective provider of dial-a-ride services. A number of taxicab companies now provide publicly funded dial-a-ride service either for the general public or for special user groups, such as the elderly and handicapped.

The following cities have instituted dial-a-ride services for the general public:

City	Number of Participating Taxicab Companies
El Cajon, California	one
Fullerton, California	one
Westport, Connecticut	two
Hopkins, Minnesota	one
Cadillac, Michigan	one

FIGURE 2.2
GENERAL MARKETS FOR PARATRANSIT SERVICES

	Para-transit Modes						
	Hire and drive services		Hail or phone services			Prearranged ride-sharing services	
Demand characteristics	Daily Rental Car	Short-Term Rental Car	Regular Taxi	Dial-a-Ride and Hail-a-Ride	Jitney	Car Pool	Subscription Bus
Spatial (location/trip length)	• Airport access • All types	* All types	• Short trips • CBD oriented • Airport access •* Small cities * Line-haul feeder	•* Short trips •* Intrasuburb •* Intersuburb * Intra-CBD * Small cities •* Line-haul feeder	•* Tourist corridors * Home-to-work corridors * Business/commercial corridors	•* Long trips •* Home-to-work corridors * Line-haul feeder	•* Long trips •* Home-to-work corridors * Line-haul feeder
Temporal	• All hours	* All hours	• Midday 10 A.M.-4 P.M. •* Early morning/late evening •* Peak hours	•* Midday * Early morning/late evening	* Peak hours * Midday	•* Peak hours	•* Peak hours
Demographic (traveler/trip purpose)	• Out of town visitors • Business trips • Recreation trips	* Residents living in medium to high density areas — all trip purposes	• Professional & managerial workers • Out of town visitors • Housewives shopping • Low income * Limited mobility groups	•* Housewives shopping & personal business •* College students * Business trips * Limited mobility groups	•* Tourists * Workers of all income groups * Business trips * Shopping trips	•* Workers of all income groups •* Shopping in low-income areas	•* Workers of all income groups • School trips

• Present

* Additional potential

Source: Reference 1.

Publicly funded dial-a-ride services available to the elderly and handicapped have been started in the following communities:

City	Number of Participating Taxicab Companies
Portland, Oregon	two
Pittsburg, Pennsylvania	three
Danville, Illinois	two
Montgomery, Alabama	fourteen
Kingston, North Carolina	fifteen
Kansas City, Missouri	two

The United States Urban Mass Transportation Administration has expended considerable funds in research, development and demonstration projects for dial-a-ride services, including a demonstration project in Haddonfield, New Jersey, to test operating techniques and public response. Other dial-a-ride systems frequently reported are those in Davenport, Iowa; Ann Arbor, Michigan; Batavia, New York; Rochester, New York; and in Bay Ridges, Ontario (near Pickering) and Regina, Saskatchewan.

Dial-a-ride services can be provided either by taxicab-based systems or by bus- or van-based systems. The majority of the better known dial-a-ride services are bus- or van-based with the exception of Davenport, Iowa. The Royal Cab Company of Davenport operates a 24-hour many-to-many service using about thirty checker cabs, each with a capacity of seven passengers. Although the city does have a privately owned bus company (which is publicly subsidized), the paratransit service provides a significant proportion of the community's public transportation, and is financially self-supporting.

A report by Teal, R.F., Marks, J.V., and Goodhue, R. "Subsidized Shared Ride Taxi Services" (Institute of Transportation Studies, University of California, 1980) provides data on a number of publicly funded projects, principally in California. Contracts have generally been established between a public body and a taxicab company (or group of companies) for provision of subsidized dial-a-ride services to the general public at low fare. The "provider-side subsidy" arrangements contract for specified services to be provided by the service providers, who are reimbursed on the basis of in-service hours, unit of distance or other agreed upon measures.

Taxicab companies are becoming progressively involved in providing publicly funded dial-a-ride services for special user groups. These programs may be supported by specific health care programs or service programs or by a wide variety of funding agencies. "User-side subsidies" are also becoming increasingly popular, whereby the eligible user is provided with tickets or charge slips and encouraged to patronize the service provider of their choice. The provider accepts the token as either whole or partial payment for the trip and obtains reimbursement at pre-arranged rates.

There is a considerable range of variation to be found in publicly funded dial-a-ride services regarding service levels and fares. In general low service levels (longer waits and longer ride times) are consistent with lower fares and the converse also holds true. The choice of which strategy to adopt must reflect overall community objectives. It is noted, however, that in those communities where unsubsidized dial-a-ride services are operated by taxicab companies (such as Little Rock, Arkansas, and Danville, Illinois) the companies provide relatively high levels of service and fares and lower vehicle occupancies. The achievement of higher vehicle occupancies requires costly administrative and dispatching procedures and this expenditure may not be cost-effective.

A variation on the basic dial-a-ride service is a system whereby the paratransit mode serves a feeder function to conventional transit facilities. Probably the three most successful services of this type are the systems instituted in Peterborough, Ontario; St. Bernard Parish, Louisiana; and Bremerton, Washington.

The utilization of existing taxicab fleets, many of which have excess capacity, to complement the transit system is beneficial to the users and to both transportation operators. It is becoming increasingly expensive to operate conventional fixed route transit services and the high costs of operations in areas with low density demand patterns (and consequently low revenues) are difficult to justify. It is for this reason that some transit authorities in large and medium sized metropolitan areas are considering cutting back routes in suburban areas and either eliminating or reducing service in low demand areas, either in off-peak times or totally. A means whereby the transportation coverage is not eliminated is the integration of dial-a-ride, or subscription services, with the fixed route operation. Smaller vehicles can respond to telephone requests, pick up users of the system and drop them off at designated points of transfer to the scheduled transit service. Although this paratransit mode exhibits extensive benefits regarding vehicle operating costs, the combined system of paratransit feeder service and conventional transit does suffer from one important drawback: the system is not fully accessible to handicapped persons as, in most cases, the transit mode is incapable of accommodating their requirements.

The above drawback notwithstanding, a review of the taxicab feeder service mode of operation of paratransit is relevant.

The Peterborough project began as a demonstration project in 1974 providing service to two areas of the city of some 58,000. There was previously a fixed route bus service in one feeder area but the patronage was low and a deficit per passenger was estimated at approximately $2.60. The Trans-cab service was popular and indicated, in 1976, that a lower deficit ($0.88) per passenger was attainable. The city assumed responsibility for the feeder service (following completion of the demonstration project) and provides the municipal share of the operating subsidy. It is worthy of note that the feeder service operator has indicated that the project has had beneficial results for the taxi operator and has stimulated transit use.

On home-to-transit trips the user contacts the feeder service by phone, is picked up and delivered to a transit transfer point. The user pays the total Trans-cab fare to the taxi driver and receives a transfer for the bus portion of the trip. On the bus-to-home trips riders notify the bus driver, upon boarding, that they require Trans-cab service, and pay the fare. The transit driver issues a transfer for the taxi trip and radios the relevant data to the cab dispatcher -bus route number, number of passengers and expected arrival time at the transfer point.

Available data on the Peterborough system indicates that average occupancy per taxi trip declined following the demonstration period and the cost per passenger has increased over time. It was suggested that the cause of the lower occupancy was the development of more dispersed demand patterns and the existing legislation which pays the operator on the basis of distance travelled, and therefore provides no incentive to the operator to increase occupancy. However, average occupancy has increased since 1975. The figures were 1.70 in 1975 and 1.80 in 1976. The 1979 figure was 1.93. Until 1980 each stop was considered a trip, and the occupancy calculated accordingly. In 1980 each meter charge was considered a trip (thereby decreasing the number of trips) and the average occupancy was 2.73.

The municipal authority and the operator do not perceive that the lack of a direct incentive to the operator to increase occupancy is a problem. In practice the dispatchers do arrange for shared trips where this is possible and therefore the utilization of a system whereby the operator was paid on a per passenger basis (instead of per unit distance) would not achieve significant benefits. Furthermore, the adoption of a new system of payment would cause considerable hardship to the operators who are not geared for such a radical change. A comparison of operating statistics for the Trans-cab operator between its early years of operation and 1980 are indicated in Table 2.1.

The St. Bernard Parish (Louisiana) taxicab feeder service is another example of a successful paratransit service but with very different reasons for its initiation.

Until 1973 there had been both bus and cab companies operating in St. Bernard Parish. In 1973 the last of the bus operators closed and in the period during which there was no bus service the taxicab business also suffered a decline. Although this is intuitively not rational, it is apparent that many trips that were previously made partly by bus and partly by taxi were now not made at all. The municipal government considered implementation of a bus service, however, a study indicated that the area could best be served by a combination of regular bus service and a dial-a-bus system. This system would cost more than the area could afford thus meaning that the local government would have to operate the system. As a result of these problems the taxicab company decided to establish a bus operation. It was found that cutbacks in the number and length of routes, in an attempt to keep the system viable, caused an uproar from residents in areas where service was discontinued. It was apparent that many areas of the community required some level of service but that the bus service could not economically extend into these areas. The solution to the problem was remedied by the decision to utilize taxis to bring the residents of the outlying areas to the new bus

TABLE 2.1
TRANS-CAB STATISTICS FOR 1975, 1976, 1977 AND 1980

	1975	1976	1977	1980
1. Total revenue received ($)	19,425.35	24,789.24	29,658.63	50,036.60
2. Total cost ($)	61,264.10	94,970.80	112,531.00	128,009.63
3. Total deficit ($)	41,840.75	70,181.56	82,962.37	77,973.03
4. Total number of passengers	65,574	79,908	96,797	110,812
5. Deficit per passenger ($)	0.63	0.88	0.86	0.70
6. No. of trips*	38,702	44,130	N/A	40,639
7. Average occupancy per trip	1.74	1.81	1.96	2.73**

Notes:

- all 1980 data provided by Trans-Cab, in personal communications;
- source of data, 1975, 1976 and 1977, rows 1, 2, 3, 4, 5 and 7: Stevenson, J., Trans-Cab: An Integration of Transportation Services within Urban Centres. Paper in Proceedings of the North Carolina Taxi and Transit Conference, September, 1978.

* Miller, Gerald K., Taxicab Feeder Service to Bus Transit, Transportation Research Record 650, 1977.

** occupancy now calculated on meter trips.

routes. The establishment of this feeder service was greatly facilitated by the joint ownership of the bus and the taxi company. The method of operation of the system is very similar to the Peterborough example.

A taxicab feeder service has also been established in Bremerton, Washington. In 1976 bus service on low ridership routes was replaced by paratransit service, on a contract basis between the city and a major taxi operator. Considerable cost savings were achieved by withdrawing the bus service to the low density residential areas.

Hail-a-ride Service: A variation on the dial-a-ride service is hail-a-ride. This option has, however, significant potential only in areas and times of relatively high density demand from street hailing. Conventional exclusive ride taxis can also be hailed from the street, the difference between this and hail-a-ride being that the latter is a shared ride trip. Since more than ninety percent of requests for taxi services in suburban areas and in medium and small cities is by telephone, the hail-a-ride potential exists primarily in those high density downtown cores with high volumes of business and/or tourist travel, and at transportation terminals such as airport, railway stations, bus depots and possibly docks.

The adoption of hail-a-ride services is severly hindered in many cities both in Canada and the United States by restrictions on shared riding. Furthermore, some cities prohibit street hailing of vehicles.

Probably the most significant adoption of hail-a-ride services in North America occurred in Washington D.C. in 1974. District taxicabs had long had a very active downtown hail business, but until 1974 the service was exclusive-ride: the first passenger or group of passengers in a taxicab had the right to insist that they be taken directly to their destination before the driver could pick up any additional passengers. In response to the 1974 disruption in gasoline supplies, taxicabs in the D.C. were allowed to pick up additional passengers without first obtaining the consent of passengers already in the cab. This hail-a-ride service has continued to the present time as the standard D.C. taxi service, and appears to be highly satisfactory to both passengers and drivers. It should be noted that the conversion from conventional exclusive-ride to shared-ride services in the D.C. was greatly facilitated by the existence of a zone fare system. Efforts to introduce similar shared ride services in nearby Arlington (Virginia) foundered on the problem of formulating a shared-ride fare structure in the presence of an exclusive-ride fare computed by standard taximeters.

A recent expression of interest in adoption of hail-a-ride taxi services occurred in April 1980 in New York City. Having made special regulatory provisions to permit shared riding in taxicabs during a transit strike, the regulatory authority (the New York Taxi and Limousine Commission) is considering making permanent provision for such services during rush hours. The fare structure for this hail-a-ride service is presenting problems as the cabs currently use taximeters and an appropriate pricing policy for shared ride passengers must be determined which is both equitable for the passengers and easily adoptable by the operators.

As previously mentioned, hail-a-ride services have potential at airports, and depending on applicable regulations, can be relatively easily organized at these sites. Several potential passengers frequently wish to travel to destinations which, though different, lie in the same general direction. To the extent that these passengers can be given the opportunity to travel together, they can obtain lower fares and the taxicab driver can obtain higher revenue; an outcome which is to the advantage of all. Logan Airport in Boston and La Guardia Airport in New York are currently experimenting with schemes to facilitate shared riding from airport terminals to certain destinations in their respective metropolitan areas.

Jitney Service: Jitney service is a paratransit service characterized by operation on fixed or semi-fixed routes with short headways. The service operates on corridors with relatively high demand densities. For the service to be viable the demand must obviously be sufficient to support a fleet of small vehicles operating without schedules on headways of less than about ten minutes. If demand is not sufficient to ensure the economic viability of the jitney service other options such as a dial-a-ride service may be more appropriate.

Jitney services are certainly not a new innovation in the paratransit field. Services were common in many American cities in the 1920's but due to being considered as unfair competition to street car services (many of which were operated by the municipalities) they were almost all legislated out of existence. The streetcar companies were traditionally given monopolistic rights on those routes that were highly profitable and, in return, they had to use some of their profits to provide services on other routes, generally unprofitable but considered necessary. Now that conventional bus services operate at a deficit on all routes, generally speaking, the earlier rationale for outlawing jitney services can no longer be considered applicable.

There are still some jitney services operating in cities in the United States, most notably in Atlantic City and San Francisco and in certain low income areas of Pittsburg and Chattanooga.

Conventional Transit: A paratransit mode that has received very little attention to date is the utilization of paratransit vehicles to provide service on conventional fixed routes with fixed schedules. This option would appear to be a cost effective approach to providing a transit service in times and areas of low demand density. This scheme has been adopted in some cities in West Germany with the vehicles operating under contract to the public authorities. In a similar manner, North American transit authorities could contract with taxicab companies to operate on specified routes and schedules in lieu of large unprofitable transit buses. The compensation to the paratransit operator could be on the basis of fixed rates per hour, per mile or per passenger, or a combination.

2.2 Paratransit Vehicles in Service

2.2.1 General

Paratransit services cover a broad spectrum of the passenger transport market, namely the gap between the privately owned passenger cars and conventional transit. This encompasses the following modes of operations:

(a) Hire and Drive Services
  - rental cars (daily and short term)

(b) Hail or Phone Services
  - Jitney
  - Dial-a-ride
  - Taxi

(c) Prearranged or ride-sharing services
  - Subscription bus
  - Car pool

Each of the above modes has specific requirements which affect the design and operation of the vehicles performing the individual services. To date a range of vehicles has been utilized to cover all paratransit operating modes, as no one vehicle can cover the broad requirements for the various paratransit modes. Rather, a variety of commercial and custom built vehicles, originally intended for other applications, have been used or adapted for utilization in various paratransit modes.

2.2.2 Vehicle Classification System

In order to simplify the analysis of vehicles used in paratransit service, it is desirable to develop a vehicle classification system, and relate it to the various paratransit operating modes.

Figure 2.3 presents a matrix which relates vehicle classifications to paratransit operating modes. As indicated on Figure 2.3, five classes of vehicles ranging in size from a standard passenger car through to a small bus are utilized to cover the range of paratransit operating modes. These five classes of vehicles are discussed individually, based upon their performance, design and technology. In discussing the vehicles, two types of manufacturers will be considered, the Original Equipment Manufacturer (OEM), who completes the entire vehicle in a single operation and the Two Stage Manufacturer (TSM) who buys a chassis from an OEM and completes it by installing a passenger-carrying compartment on it.

Paratransit services are provided for a nonhomogeneous group of riders. In addition to average riders, there is a large group of people who are defined as transportation disadvantaged, who use paratransit services. This includes the elderly and handicapped (E & H) passengers. The requirement to make paratransit services readily accessible to this group affects the design of vehicles, particularly for the transport of wheelchairs. To date the E & H requirement has been accommodated mainly by modifying existing vehicles rather than the production of a new type of vehicle.

FIGURE 2.3

CLASSIFICATION OF VEHICLES USED IN PARATRANSIT SERVICE

VEHICLE TYPE	TRANSPORTATION MODES							
	PRIVATE AUTO	PARATRANSIT SERVICES						CONVENTIONAL TRANSIT
		Hire & Drive	Hail or Phone			Pre-arranged Ride Sharing		
		Rental Vehicle	Taxi	Dial-a-ride	Jitney	Car Pool	Subscr. Bus	
Passenger Car	Outside Scope of this Study	F	F	F	F	F		Outside Scope of this Study
Special Taxi Vehicle			F	O	O			
Standard MPV		O		O	O	F	O	
Modified MPV				F	O	O	O	
Small Bus				O			F	

NOTE: MPV - multipurpose passenger vehicle
F - denotes frequent useage
O - denotes occasional useage

The following subsections describe each of the five classes of vehicles currently used in paratransit applications in terms of the following attributes:

- general characteristics
- exterior dimensions
- seating capacity
- interior dimensions
- technology
    - body
    - power plant and drive train
- special equipment
    - communications
    - control
    - fare
    - E & H loading/unloading
    - restraint systems
- modal useage and special modifications

It should be noted that the vehicle market is undergoing considerable change due to downsizing/fuel economy and emissions pressures, making vehicle design predictions difficult.

2.2.3 Passenger Cars

As indicated on Figure 2.3, the passenger car finds frequent application in five out of six of the paratransit operating modes.

Passenger cars are categorized into several classifications, based upon size, and the Motor Vehicle Manufacturer's size classification is utilized in this report:

- Luxury
- Full Size
- Intermediate
- Compact
- Subcompact

The categories other than full size find application in paratransit services only as rental cars, and therefore the emphasis in this section will be on full size passenger cars.

Since the onset of mass production of the North American passenger car it has steadily grown to its maximum size plateau during the 1960's. Since the mid 1970's the downsizing trend brought about by the dwindling supply and increased cost of petroleum fuels has caused a dramatic change in the "full-sized" North American passenger car.

The general characteristics of the full size 1981 North American passenger car suitable for use in paratransit operations include:

- four doors
- seating capacity (total 6 - 3 front, 3 rear)
- body (formed mild steel panels)
- power plant
  - in line 6 cylinder
  - V 6 configuration
  - V 8 configuration
- drive train
  - automatic 3 speed or 4 speed transmission, with optional torque converter lockup in fourth gear.
  - rear wheel drive through a hypoid differential.
  - floating rear axle with non-independent rear suspension.
- interior and exterior dimensions
  - see Table 2.2 for details on typical 1981 model year full sized vehicles.

TABLE 2.2
DETAILS ON FULL SIZED PASSENGER CARS, 1981

MANUFACTURER			GENERAL MOTORS		FORD	CHRYSLER	
MODEL			CHEVROLET IMPALA	PONTIAC		PLYMOUTH GRAN FURY	DODGE DIPLOMAT
Item	Parameter	Unit					
1.	Wheelbase	cm	294.6	294.6	290.3	301.0	286.3
2.	Overall Length	cm	538.7	543.6	531.6	559.3	522.5
3.	Overall Width	cm	191.3	194.1	196.8	197.1	188.5
4.	Overall Height	cm	143.3	144.0	138.9	138.4	140.5
5.	Curb Weight	kg	1642	1404	1634	1630	1597
6.	Front Seat Headroom	cm	100.3	100.3	96.3	97.0	99.8
7.	Front Seat Legroom	cm	107.2	107.2	106.9	107.4	108.0
8.	Front Track	cm	157.0	156.7	158.0	157.2	152.4
9.	Rear Track	cm	154.4	154.2	157.5	157.5	151.1
10.	Turning Circle (Curb-to-Curb)	m	11.8	11.9	99.6	12.9	12.4

It should be noted, that unlike transit vehicles, passenger cars do not have sufficient headroom to permit passengers to stand up.

When utilized as taxis, North American passenger cars are frequently ordered with "taxi packs", which typically include the following special equipment:

- special rear axle ratio
- heavy duty electrical system (battery & alternator)
- vinyl interior
- pulls on rear doors
- warning lights for doors ajar
- heavy duty suspension

The cost of the option package ranges from $400 to $900 but will no longer be available as a specific option package from two of the three major North American manufacturers by the 1982 model year.

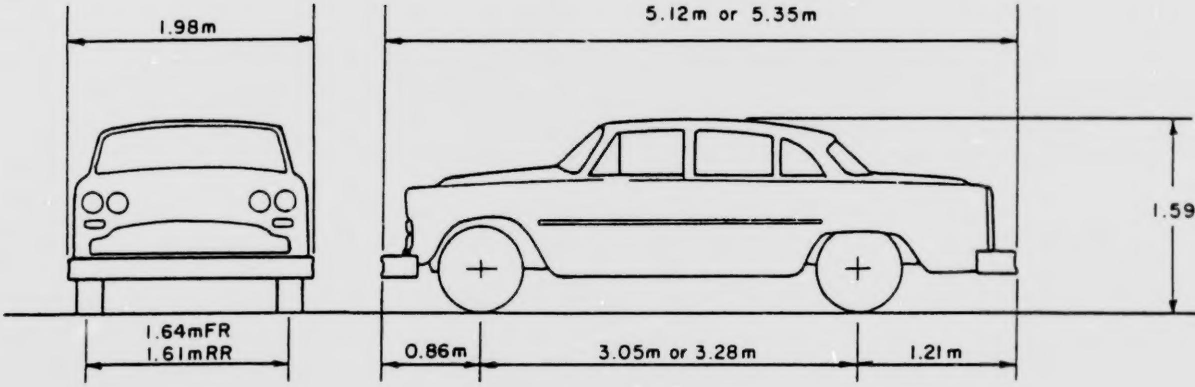
2.2.4 Special Taxi Vehicles

Prior to 1982 the only purpose-built North American taxi vehicle was the Checker Taxicab built by the Checker Motors Corporation in Kalamazoo, Michigan. The vehicle was available in two models, the A-11, which has a 304.8 cm wheelbase, 4 door sedan seating three in front and three or five in the rear, and the A11-E, on a 327.7 cm wheelbase, seating three in the front and six in the rear.

The general characteristics of the vehicle were as follows:

- four doors
- body of formed mild steel panels
- power plant (options)
  - (1) 3.8 litre, V-6, gasoline, 110 hp. at 4200 rpm
  - (2) 4.4 litre, V-8, gasoline, 115 hp. at 4000 rpm
  - (3) 5.0 litre, V-8, gasoline, 150 hp. at 3500 rpm
  - (4) 5.7 litre, V-8, diesel, 105 hp. at 3200 rpm
- drivetrain
- transmission
  - three speed automatic using torque converter and planetary gearing.
  - rear wheel drive through a hypoid differential.
  - floating rear axle with non-independent rear suspension.
- exterior dimensions (see Figure 2.4 for details).

FIGURE 2.4
DIMENSIONS OF CHECKER TAXI
(dimensions in metres)



This vehicle found wide application in the taxi mode of paratransit operation, and was manufactured at a rate of approximately 5,000 units per year. Due to its purpose-built design the Checker Cab had a long intended useful life and generally achieves an average life considerably in excess of conventional passenger cars used for taxi purposes. It is generally perceived as a roomy vehicle with good ease-of-entrance and egress plus good durability and maintainability in service. Unlike transit vehicles in service it does not have sufficient interior headroom to permit passengers to stand up. Checker Motors Corporation advised, in spring 1982, that they were ceasing production of their taxi vehicles, citing an apparent lack of demand for a purpose-built vehicle as the reason.

A similar purpose built taxi vehicle widely used in England is the Leyland "London Taxicab". The London cabs are made by Car Bodies Ltd. of Coventry which purchases the Austin FX-4 chassis from British Leyland. The production rate is about 2,000 per year and the cost of the vehicle is about the same as a similar sedan vehicle, the price being reduced to this level as no Value Added Tax is applicable for the taxis.

This vehicle is not sold in North America and despite contention that it is an efficient purpose-built vehicle, the opinion has been expressed that the taxi using public may not willingly accept such a vehicle in place of conventional North American sedans.

2.2.5 Standard Multi-Purpose Passenger Vehicles

Multi-purpose passenger vehicles (MPV) include vans, which are forward control vehicles with at least a portion of the drivers station at or forward of the front axle, and conventional control MPV's such as the GMC Suburban, and the AMC Jeep Wagoneer. These latter two vehicles, due to poor fuel economy and high price, do not find application in paratransit operations. Therefore this section is restricted to a review of forward control vans of standard commercial manufacture.

The typical North American van as manufactured by Dodge, Ford, Chevrolet and GMC has found common application in five out of the six operating modes indicated in Figure 2.3. The seating capacity of these vehicles ranges from 5 passengers on the smaller 279.4 cm wheelbase models up to 15 passengers on the extended models with a 322.6 cm wheelbase. It should be noted, that for the purposes of the Motor Vehicle Safety Act (both in the U.S. and Canada) vehicles with more than 10 seating positions are considered a bus, but these larger capacity vehicles are considered as vans in the context of this report. Once again the limited interior headroom of approximately 135 cm does not permit passengers to stand up, as is possible on transit vehicles. Due to the limited headroom and height at the rear and side entrances of approximately 122 cm the standard vehicle is not suitable for wheelchair lifts. The general characteristics of the MVP are as follows:

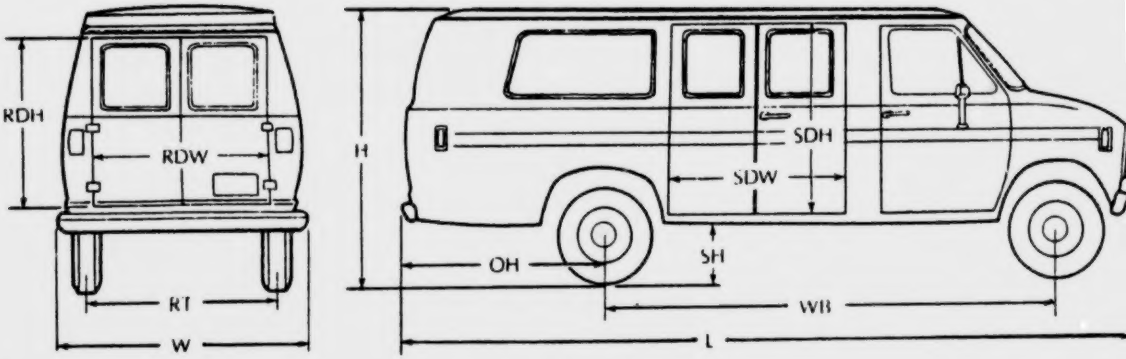
- four doors, two in drivers area, plus large rear door and large curb-side door.
- body-formed mild steel panels.
- power plant (6 cylinder and 8 cylinder configurations ranging from 3.7 to 5.7 litres, gasoline fuelled).
- transmission - (3 speed automatic transmission using torque converter and planetary gearing)
- rear wheel drive through a hypoid differential
- non-independent rear suspension

Figure 2.5 and Table 2.3 indicate typical exterior dimensions for 1980 and 1981 Model year vans, while Figure 2.6 and Table 2.4 indicate interior dimension data. Figure 2.7 indicates common interior layouts of vans of various wheelbase lengths. When compared with the wheelchair space requirements as indicated in Figure 2.8(a) and (b), the following conclusions can be drawn:

- wheelchair positions are limited within the van
- wheelchairs cannot face each other from opposite sides of the van
- two wheelchairs cannot be accommodated between the rear wheel wells of the van.

FIGURE 2.5

EXTERIOR DIMENSIONS FOR STANDARD PRODUCTION VANS



Source: Adapted from Reference 2

TABLE 2.3

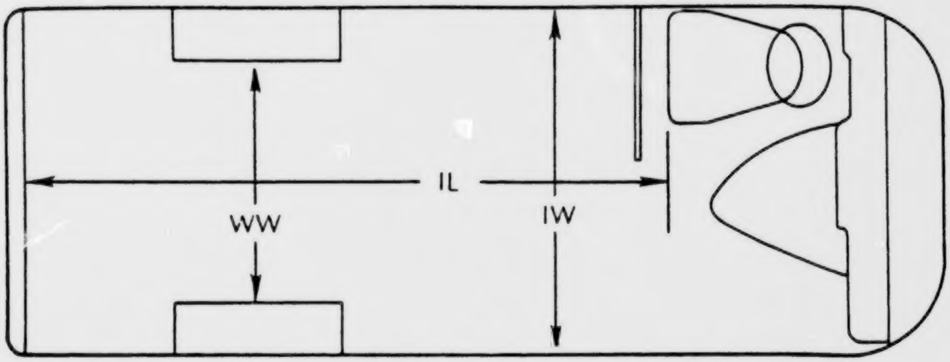
EXTERIOR DIMENSIONS FOR STANDARD VANS

Model	CHEVROLET & GMC			DODGE			FORD		
	G20	G20	G30	B200	B300	B300 Maxivan	E150	E250	E350 Supervan
Gross Vehicle Weight GVW (kg)	2993.7	2993.7	3900.9	2744.2	3265.9	3878.2	NA	NA	NA
Wheelbase WB (cm)	279.4	317.5	317.5	219.2	324.1	324.1	315.0	350.5	350.5
Overall Length L (cm)	452.6	513.6	513.6	454.4	499.4	566.2	474.5	525.3	576.1
Overall Width W (cm)	202.0	202.0	202.0	202.7	202.7	202.7	202.7	202.7	202.7
Overall Height H (cm)	203.7	203.7	206.2	202.2	205.5	204.7	204.5	208.3	212.6
Rear Overhang OH (cm)	122.0	122.0	122.0	101.6	101.6	154.9	96.0	111.2	162.1
Rear Track RT (cm)	172.7	172.7	172.7	165.6	165.6	165.6	170.2	167.6	167.6
Step Height SH (cm)	50.8	50.8	50.8	50.8	50.8	50.8	50.8	50.8	50.3
Side Door (Hinged)									
Width SDW (cm)	NA	NA	NA	125.2	125.2	125.2	NA	NA	NA
Height SDH (cm)	NA	NA	NA	119.9	119.9	119.9	NA	NA	NA
Side Door (Sliding)									
Width SDW (cm)	112.3	112.3	112.3	101.1	101.1	101.1	121.9	121.9	121.9
Height SDH (cm)	125.0	125.0	125.0	119.9	119.9	119.9	121.9	121.9	121.9
Rear Door									
Width RDW (cm)	138.2	138.2	138.2	125.2	125.2	125.2	137.2	137.2	137.2
Height RDH (cm)	124.0	124.0	124.0	119.9	119.9	119.9	121.7	121.7	121.7
Turning Diamater at Front Bumper (m)	13.28	14.78	14.21	NA	NA	NA	13.50	15.15	16.86

NA = Not Available

Source: Adapted from Reference 2

FIGURE 2.6
INTERIOR DIMENSIONS FOR STANDARD VANS



Source: Adapted from Reference 2

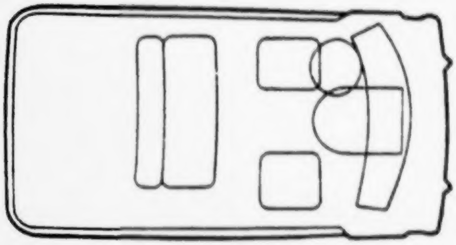
TABLE 2.4
INTERIOR DIMENSIONS FOR STANDARD VANS

	CHEVROLET & GMC			DODGE			FORD		
Model	G20	G20	G30	B200	B300	B300	E150	E250	E350
Wheelbase WB	110	125	125	109.6	127.6	127.6	124	138	138
Length - back of front seat to rear door at shoulder height IL (cms)	239.3	300.2	300.2	236.0	281.7	347.7	231.6	282.4	333.2
Width at shoulder height IW (cms)	179.8	179.8	179.8	175.3	175.3	175.3	179.3	179.3	179.3
Width between wheel-housings WW (cms)	135.9	135.9	135.9	127.0	127.0	127.0	121.9	121.9	121.9
Maximum interior height floor to roof (cms)	136.4	136.7	136.7	135.1	135.1	135.1	131.1	131.1	131.1

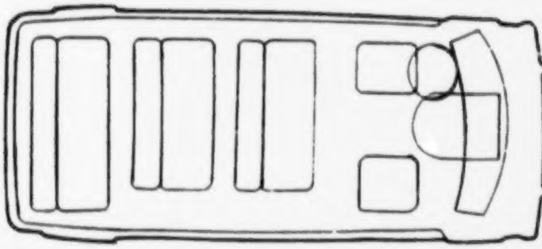
Source: Adapted from Reference 2

FIGURE 2.7

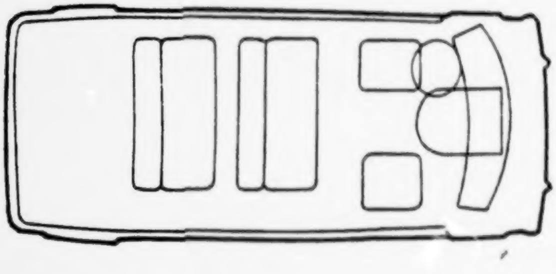
SEATING ARRANGEMENTS FOR STANDARD VANS



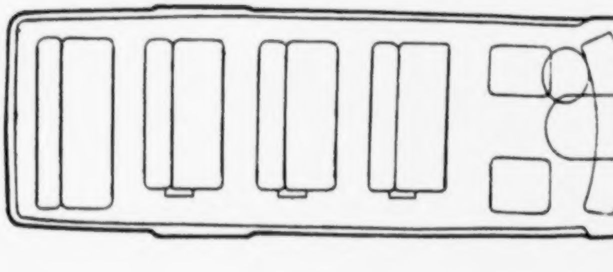
Five Passenger 2.79 m Wheelbase



Twelve Passenger 3.24 m Wheelbase



Eight Passenger 3.24 m Wheelbase

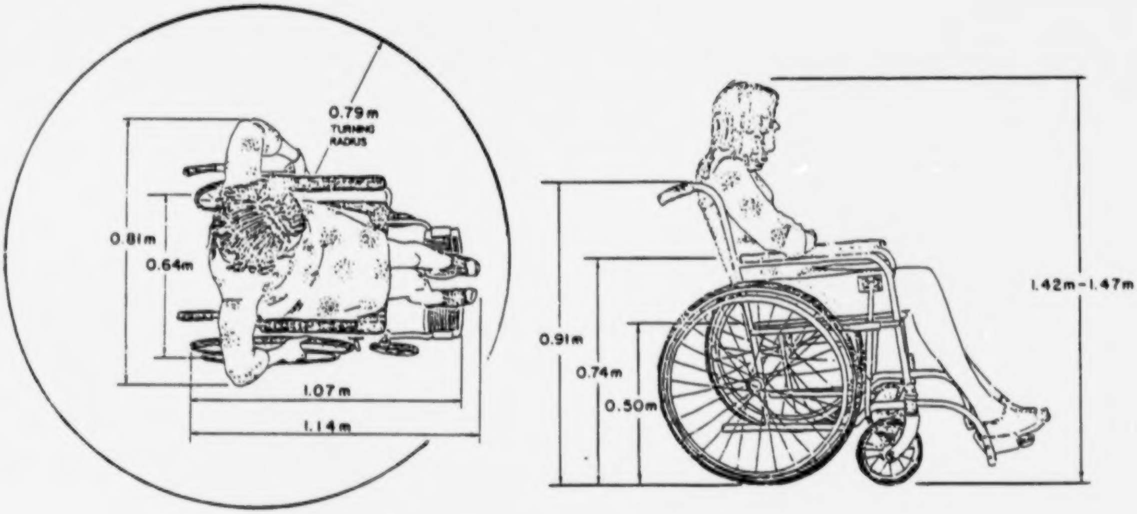


Fifteen Passenger 3.24 m or
3.51 m Wheelbase

Source: Adapted from Reference 2

FIGURE 2.8 (a) AND (b)

WHEELCHAIR SPACE REQUIREMENTS



(a) (b)

Source: Reference 3

The 50.8 cm step height from the ground to the van floor makes entrance and egress difficult for the elderly and handicapped. In addition, for the high seating capacity vans, the combination of the low headroom (135 cm) and narrow side aisle way (25.4 cm) makes access difficult for passengers with mobility impairments.

These standard production vans have been used successfully for specific paratransit modes, but have distinct disadvantages in providing transportation for passengers with mobility impairments.

The disadvantages arise from the fact that access to the van is made difficult by the high first step and low roof. The low roof also inhibits movement within the van, particularly to and from seats in the rear of the vehicle. If a lift or a ramp is stored in the vehicle, it often protrudes into the seating area. Also, the wheelchair passenger and lift attendant must bend over in order to clear the roof on entry and exit.

2.2.6 Modified Multi-Purpose Passenger Vehicles

Modified vans were developed by the aftermarket to improve the utility of vans in a number of applications, including paratransit, and as indicated in Figure 2.3, they are used in four out of six paratransit operating modes. These modified vans have the same basic configuration and propulsion system technology as the standard vans from which they are built. They are standard production vans which have been altered, typically to increase headroom, widen the body, or make the vehicle more accessible to wheelchair passengers. These modifications are carried out by companies such as:

(a) Para Industries Ltd.,
74 Jamie Avenue,
Ottawa, Ontario

(b) Funcraft Ltd.,
165 Sheldon Drive
Cambridge, Ontario

(c) Campwagon Ltd.,
1170 Ch. Olivies
St. Nicholas, Quebec

(d) Autobus Girardin Ltee
Drummondville, Quebec

(e) Curtis Industries
Coburg, Ontario

In the U.S., it is estimated that more than forty companies convert a total of 5,000 vans per year for paratransit services.

These vehicles have basic chassis configuration driveline and steering performance virtually identical to the vans of Section 2.2.5, upon which they are based.

One common modification is the addition of a raised roof to increase the interior headroom. This is accomplished by removing the standard roof at or below the roof line and replacing it with a steel, aluminum, or fibreglass raised roof section, allowing for headroom up to 188 cm. Other modifications include the addition of wheelchair lifts and restraint systems, transit-type double passenger seats, sliding passenger seats and lower rise steps at the main passenger entrance. Other modifications utilized to improve passenger comfort and safety include:

- hand holds at entrances, on seatbacks, etc.
- protective padding on hard surfaces
- roof ventilation for warm weather operation
- wall insulation for cold weather operation

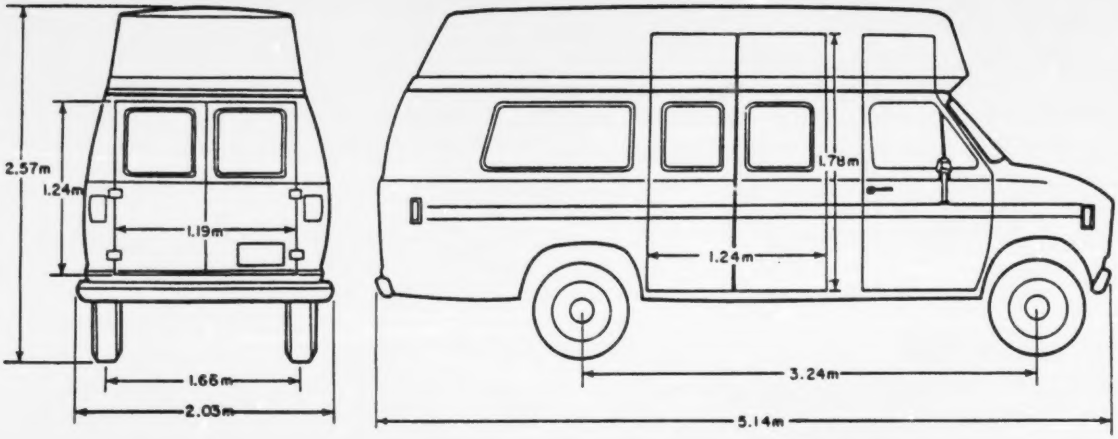
Any major modification to a standard van may alter the structural integrity of the vehicle, and special attention is required in using high quality materials and workmanship to avoid degradation in the safe operation of the vehicle. A wide variety of modified vans exist due to the difference in design used by modifiers and the number of different base vans available. Figure 2.9 indicates typical exterior dimensions for a modified van while Figure 2.10 indicates typical interior seating arrangements for a modified twelve passenger van without a lift and side cargo door. When the capability to load wheelchairs is added, through a lift, or ramp, a variety of mixed seating/wheelchair stations is possible, as indicated on Figure 2.11 through 2.16.

Perimeter (aisle-facing) seats provide easier access for passengers who are mobility handicapped. However, vehicle manoeuvres involving lateral acceleration cause discomfort for passengers in aisle-facing seats, particularly with elderly and handicapped passengers. Each additional wheelchair transported will generally eliminate two passenger seats unless fold-up seats are used with wheelchair restraints. A side mounted wheelchair lift also generally eliminates two passenger seats, while a rear-mounted lift commonly eliminates the last row, or three seats.

The flexibility of a modified van to carry both ambulatory and wheelchair passengers is enhanced through the use of folding (flip-up) or removable (quick-release) seats, which can be coordinated with wheelchair restraints. Vans with these features have found wide use, and good acceptance in paratransit services, particularly in the transport of elderly and handicapped passengers.

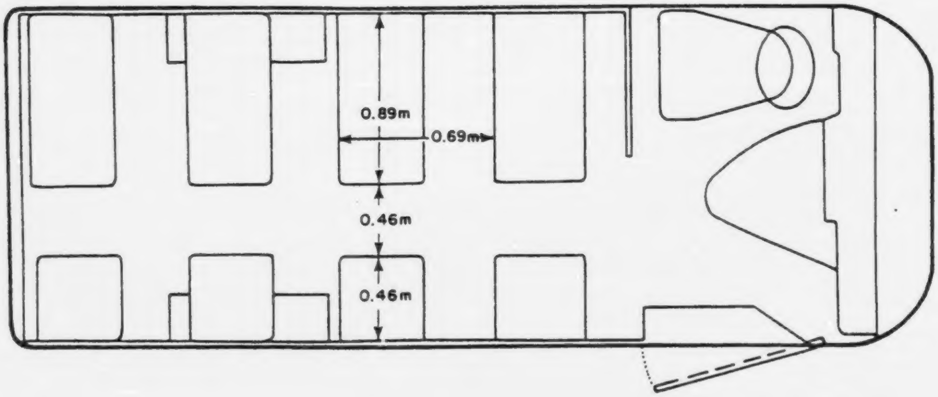
It is probable that downsizing trends now evident in the auto industry could reduce the usefulness of the van and modified van as a paratransit vehicle.

FIGURE 2.9
TYPICAL EXTERIOR DIMENSIONS FOR A MODIFIED VAN



Source: Adapted from Reference 2

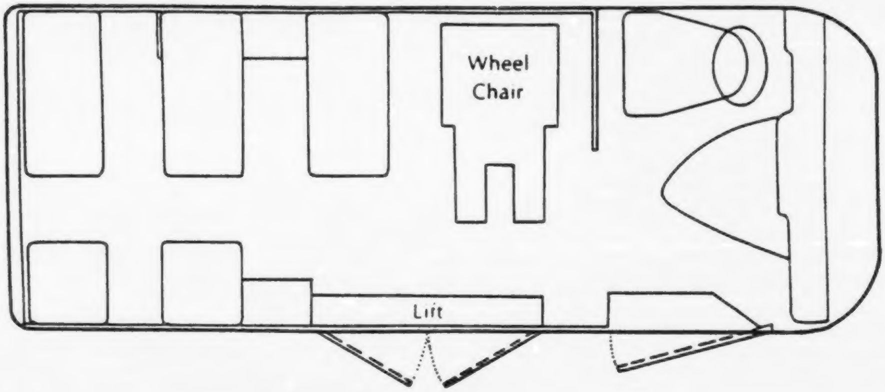
FIGURE 2.10
TYPICAL TRANSIT-TYPE SEATING ARRANGEMENT FOR 12 PASSENGER MODIFIED VAN WITHOUT LIFT



Source: Adapted from Reference 2

FIGURE 2.11

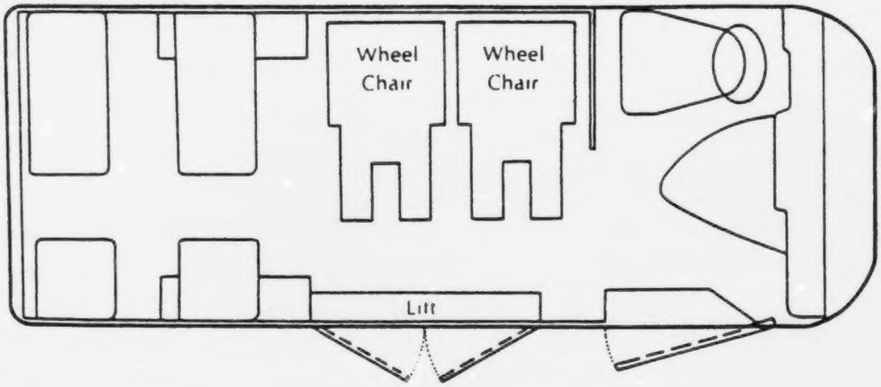
TYPICAL SEATING ARRANGEMENT FOR MODIFIED VAN: EIGHT STANDARD SEATS PLUS ONE WHEELCHAIR POSITION



Source: Adapted from Reference 2

FIGURE 2.12

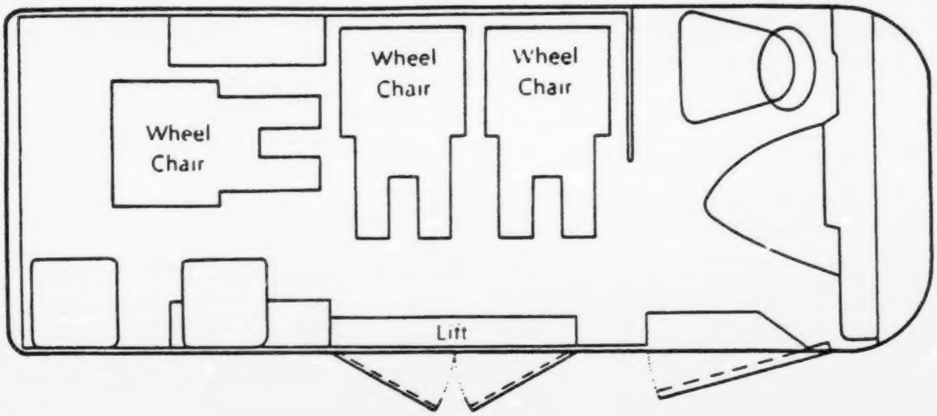
TYPICAL SEATING ARRANGEMENT FOR MODIFIED VAN: SIX STANDARD SEATS PLUS TWO WHEELCHAIR POSITIONS



Source: Adapted from Reference 2

FIGURE 2.13

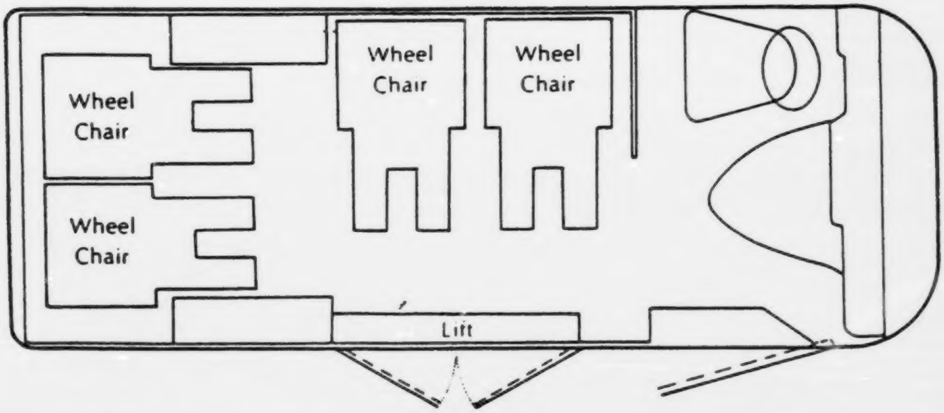
TYPICAL SEATING ARRANGEMENT FOR MODIFIED VAN: TWO STANDARD SEATS PLUS THREE WHEELCHAIRS



Source: Adapted from Reference 2

FIGURE 2.14

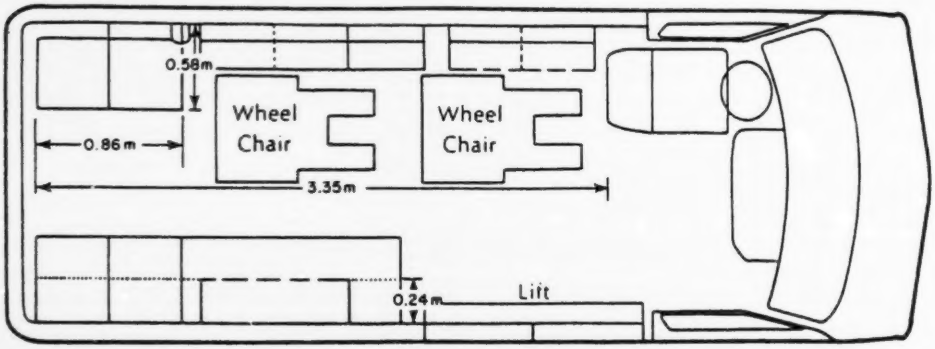
TYPICAL MODIFIED VAN WITH FOUR WHEELCHAIR POSITIONS



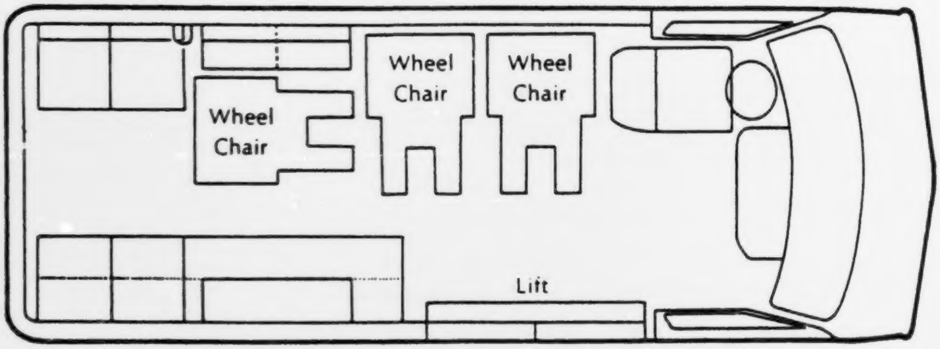
Source: Adapted from Reference 2

FIGURE 2.15

TYPICAL MODIFIED VAN WITH PERIMETER "FLIP-TYPE" SEATING



TWO WHEELCHAIR POSITIONS

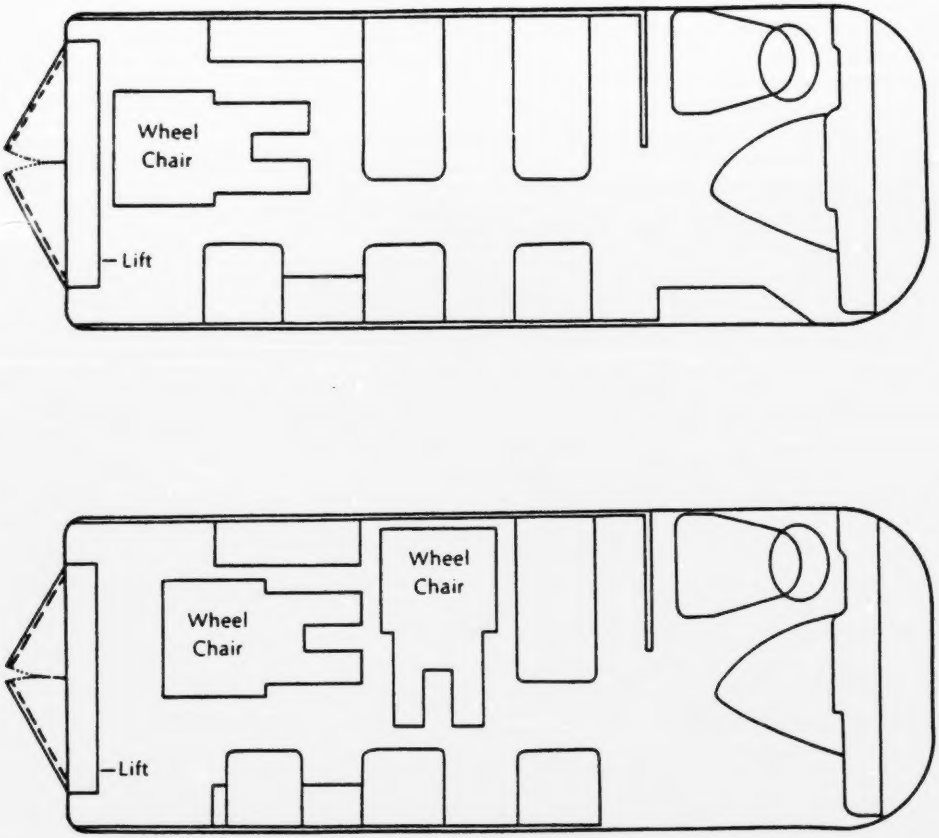


THREE WHEELCHAIR POSITIONS

Source: Adapted from Reference 2

FIGURE 2.16

SEATING ARRANGEMENTS FOR MODIFIED VAN WITH LIFT AT REAR OF VEHICLE



Source: Adapted from Reference 2

2.2.7 Small Buses

As indicated on Figure 2.3 small buses are used in two out of six paratransit operating modes. This class of vehicle is either manufactured as a "body on-chassis", where a second manufacturer normally installs a custom-made passenger compartment on a chassis typically produced by Chevrolet, Chrysler, Ford or GMC, or a bus manufacturer making the complete unit.

The body of these vehicles is typically constructed around a steel frame attached to the chassis, which has a wheelbase ranging from 318 cm to 425 cm, and a gross vehicle weight rating of 4536 kg to 8165 kg. Two general size classes are available, 12 to 16 passengers and 16 to 22 passengers. Because of the increased size of these vehicles they can easily accommodate wheelchair passengers or a mix of wheelchair and ambulatory passengers. The increased size also limits road manoeuverability somewhat. The general characteristics of the small bus are as follows:

- two doors plus emergency exit
- body - formed from mild steel panels
- power plant - gasoline 6 or 8 cylinder with limited diesel options
- drivetrain
- transmission - 3 or 4 speed automatic, torque converter plus planetary gearing
- rear wheel drive through a hypoid differential
- non-independent rear suspension

Canadian manufacturers/importers of this size of vehicle include:

- Superior Bus Manufacturing Company
  P.O. Box 460,
  Morris, Manitoba

- Wayne Corporation, Wayne Transportation Division
  Welles Corp. Ltd., 2650 Metcalfe St.,
  Windsor, Ontario

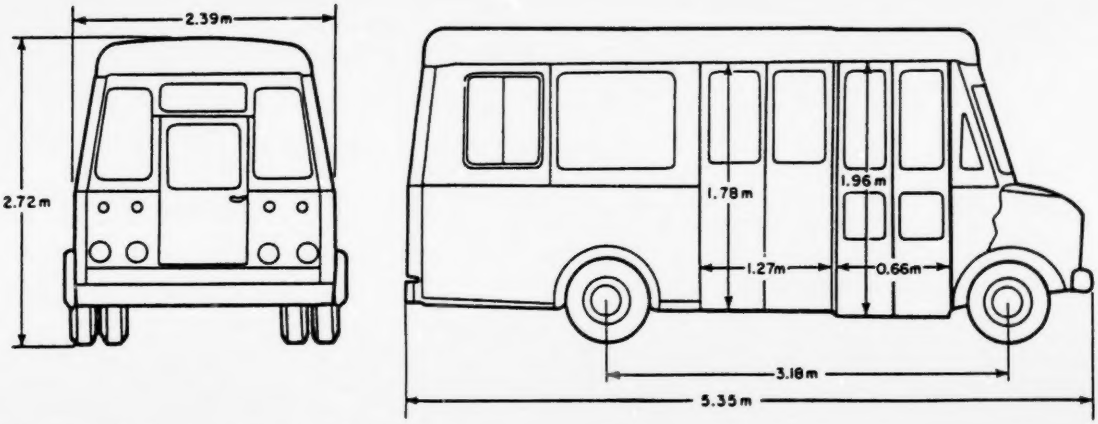
- Bluebird Quebec Ltee.,
  C.P. 400,
  Ville des Laurentides, Quebec

- Thomas Built Buses of Canada Ltd.,
  P.O. Box 580
  Woodstock, Ontario

Figures 2.17 and 2.18 indicate the exterior dimensions for two typical small buses. In addition Figures 2.19 and 2.20 indicate typical interior dimensions and seating arrangements for 12 passenger and 20 passenger small buses respectively.

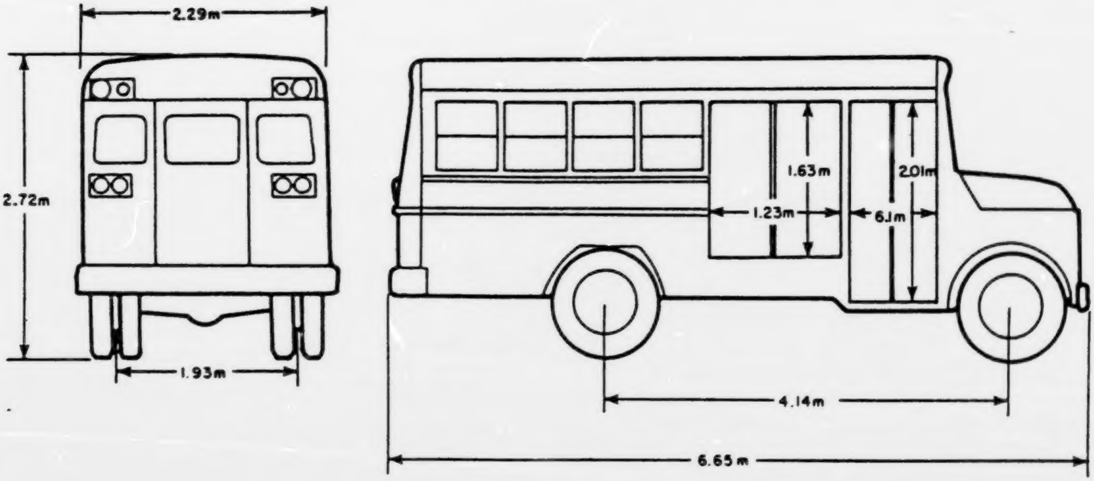
These vehicles have wide application, particularly in the transport of the handicapped and have shown good performance in this role.

FIGURE 2.17
TYPICAL EXTERIOR DIMENSIONS FOR A 12 PASSENGER SMALL BUS



Source: Adapted from Reference 2

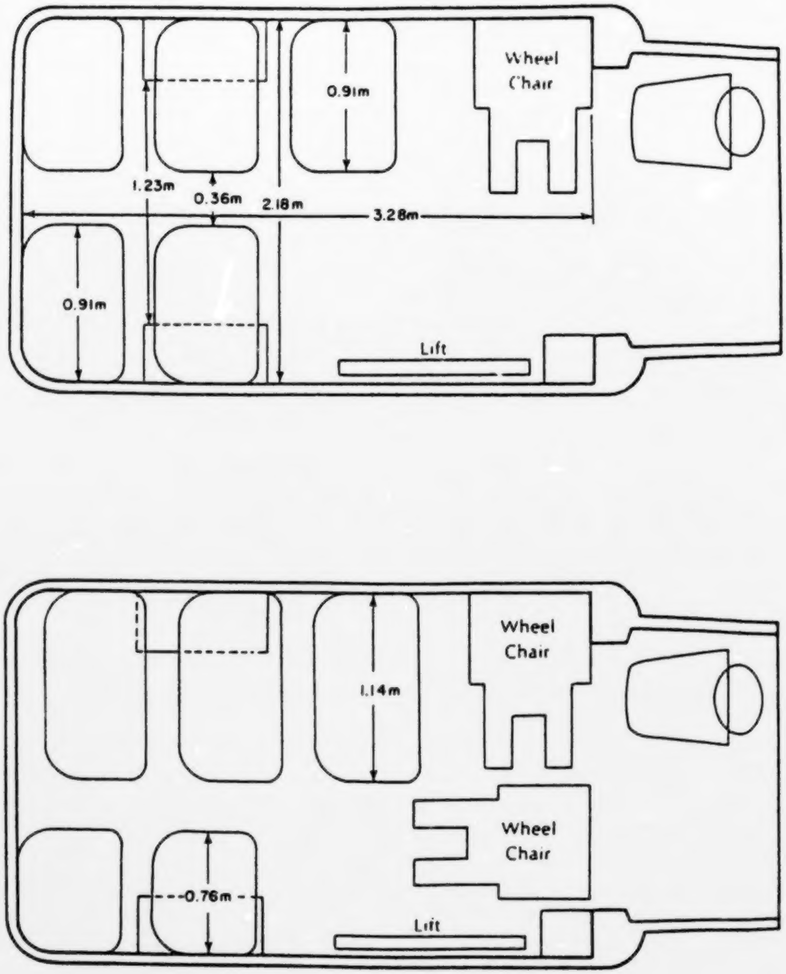
FIGURE 2.18
TYPICAL EXTERIOR DIMENSIONS FOR A 20 PASSENGER SMALL BUS



Source: Adapted from Reference 2

FIGURE 2.19

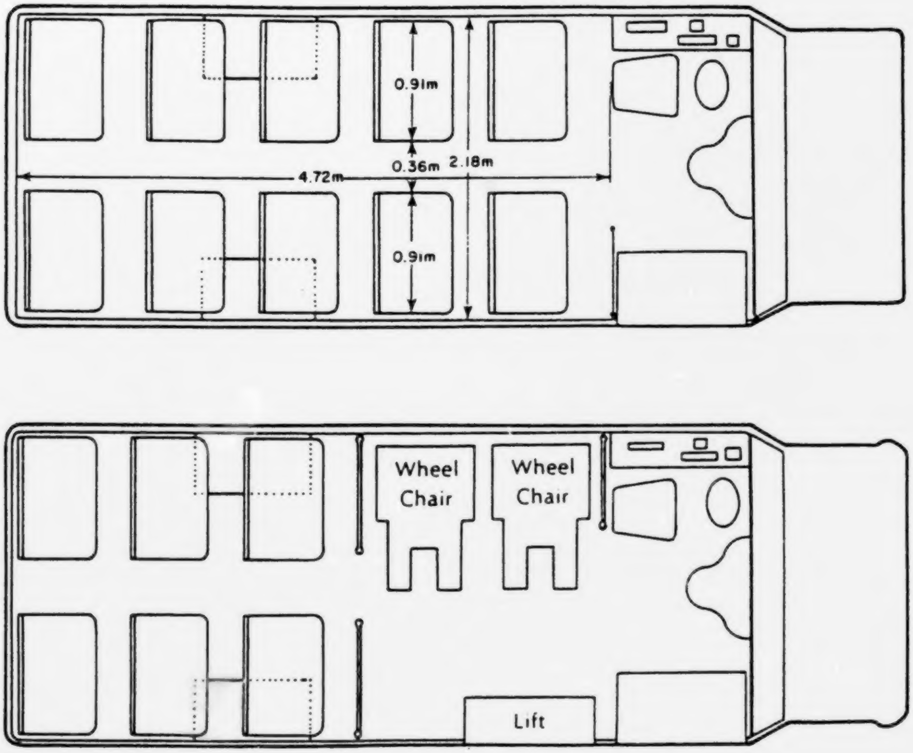
TYPICAL INTERIOR DIMENSIONS AND SEATING ARRANGEMENTS FOR A 12 PASSENGER SMALL BUS



Source: Adapted from Reference 2

FIGURE 2.20

TYPICAL INTERIOR DIMENSIONS AND SEATING ARRANGEMENTS FOR A 20 PASSENGER SMALL BUS



Source: Adapted from Reference 2

2.2.8 Ancillary Equipment

Ancillary equipment is frequently fitted to conventional vehicles either used or modified for paratransit roles, and the following equipment finds use in one or more of the paratransit categories shown in Figure 2.3.

1. Security Shield (Taxi Only)
2. Mission/Status Display (External)
3. Fare Collection and Protection Equipment
4. Communication with Dispatcher Equipment
5. Supplementary Luggage Accommodation
6. Exterior Advertising

The taxi cab industry's experience in New York with the introduction of security shields and partitions between the front and the rear seats of taxi cabs indicates a substantial reduction in crime. A 0.95 cm polycarbonate panel will stop small fire arms including a 45 calibre bullet. The conventional partition design consists of a clear plastic upper panel assembly extending to the "B" pillar and steel shield from the top of the seat back to the floor. These materials are so highly bullet resistant there have been virtually no instances of assailants firing at drivers from the back seat in New York City. However, the total separation between the front and the rear seats causes a number of problems, namely:

1. HVAC - In standard sedans and vans the heating ventilating air conditioner equipment is located in front of the driver consequently the shield reduces the efficiency of this equipment for rear compartment environmental control.

2. Acoustics - Acoustics are adversely affected by the solid barrier and voice communications between the driver and passenger are poor.

3. Partition "Lower" - often the lower steel portion of the shield is installed in a fixed position at the rearmost seat position with a resulting loss of passenger space from the rear compartment.

4. Partition "Upper" - The upper clear section of the partition causes problems in the driver vision. Depending on the angle of installation, the partition can cause problems of reflections particularly at night. In addition, the relatively soft surface of polycarbonate plastic sheet is subject to scratching and abrasion resulting in considerable loss of optical clarity with increasing use.

2.2.9 Exterior Mission Status Display Equipment

External mission display equipment in North America is primarily a rooftop mounted "roof-light" sometimes supplemented by various hand lettered signs attached to the sun visor. The roof light is usually a vacuum-formed thermo plastic dome with lettering and is internally illuminated by one or more incandescent lamps, usually lit to indicate availability. Its effectiveness is limited in bright sunlight. In New York City the display is regulated by the

Taxicab Licensing Commission and is more sophisticated as it incorporates a sunshield to retain day time visibility of the taxi display on the front and the identifying medallion number on the rear. In addition it incorporates an "off duty" sign and an "on radio call" sign, the latter to aid in enforcement of laws against drivers ignoring hails. Current roof lights incorporate high level directional signals and forward flashers. Exterior mission status display devices may be of use in indicating routing and seat availability with shared-ride vehicles.

2.2.10 Fare Collection and Protection Equipment

Historically the electro-mechanical meter driven by the speedometer cable has been used to meter distance with a clutch mechanism to engage the time clock below a certain speed. In recent years improvements have included electric triggering devices with solid state technology enabling a substantial reduction in the size of the meter. A recent study evaluated two digital meters tied to a two-way radio to facilitate multiple passenger riding. Upon responding to a call, the meter display shows the cost for an estimated trip time when the passengers board. Thus the passenger avoids uncertainty regarding over-charging, the operator has full electronic recording of group riding and the customer can ride less expensively. Taxi meter manufacturers who are marketing a solid state unit are suggesting that this technology readily offers the flexibility of multiple tariffs with radio facilitated computer control to provide a ready means of accommodating group rides.

2.2.11 Communication with Dispatcher

Communication between the dispatcher and vehicle driver has traditionally utilized a mobile two-way radio. Recently an advanced taxi dispatch system has been developed by Canada Systems Group and is presently in use at Blue Line Taxi in Ottawa in several hundred cars. Through a digital adapter the standard taxi radio interfaces to a one-line message display and a small key pad, with a voice capacity for emergencies. Telephone orders for taxis are entered by clerks into a computer which automatically allocates them to districts within the city, relays the orders to taxis in that district and displays the details to the driver.

The system has reduced the number of dispatchers from four to one, has reduced busy signals on the incoming phone lines and has greatly improved the efficiency of the dispatch operation. It may well be an indication of the future method of dispatch within the industry.

2.2.12 Exterior Advertising

Exterior advertising devices are a standard feature of transit vehicles from taxis to buses. A number of cities currently are using roof-top illuminated advertising. Current exterior illuminated advertising on buses is so placed to obstruct the vision of standees, making visual siting of street names difficult. Triangular roof top advertising carriers on taxi cabs have a substantial impact on vision on the street traffic scene. For these reasons the exterior advertising carrier unit should be incorporated into the vehicle design so that such equipment is better integrated structurally and functionally.

2.3 Paratransit Vehicles in Development

In this section new paratransit vehicles which are not currently in use in North America are discussed. Purpose-designed vehicles, which have been developed to serve some aspect of the paratransit market are reviewed, the state-of-the-art of European paratransit vehicles is examined briefly and finally the impact of downsizing of standard vehicles used in paratransit service is examined.

2.3.1 The GSM Taxi

The Montreal-based industrial design firm of Guillon, Smith, Marquart & Associes, decided on its own initiative in 1975, to investigate the apparent lack of a vehicle suitable for taxi service in North America. As the result of a detailed investigation of the requirements for a taxi, the design definition was worked out for a taxi in 1976, including all relevant interior and exterior dimensions, and a basic configuration. Subsequently a full scale design mock-up was fabricated to confirm the design concept. A prototype vehicle was then assembled and demonstrated at the Roads and Transportation Association of Canada Conference in September 1980, by Mr. M.L. Smith of GSM Taxi Ltd., a branch of the original firm. At the time of writing of this report, GSM taxi was in the process of arranging funding for a pilot production of 100 vehicles for both the U.S. and Canadian markets.

The GSM vehicle shown in Figure 2.21(a) and (b) is a purpose-built taxi fabricated with proven commercial components in the suspension, and power train. The vehicle is of front-engine rear-drive design. The passenger area, as shown in Figure 2.22, has adequate space for up to five passengers, with two facing rearward on folding "jump seats". When a wheelchair is located in the passenger area, two passengers can be seated.

The vehicle has a sturdy frame for continuous duty operation, and can be equipped with either a gasoline or diesel engine. (See specifications, Table 2.5). An automatic three speed transmission, and central drive shaft connect to a live rear axle to complete the power train. An optional 4 cylinder Deutz diesel engine will be offered at a proposed cost premium of less than $2,000. The suspension components are from a light duty truck. The front and rear suspension utilize coil springs, hydraulic shock absorbers, and control arms. The rear coil springs and control arms are designed to enable greater wheel travel for improved ride and stability over rough surfaces.

The frame and body system, shown in Figure 2.23, are unique in a taxi application.

The frame consists of two longitudinal members connected by a series of cross-members. A sub-frame is fitted to the main frame to support the perimeter bumper system, which minimizes body damage and greatly improves the repairability of the body.

FIGURE 2.21
THE GSM TAXI

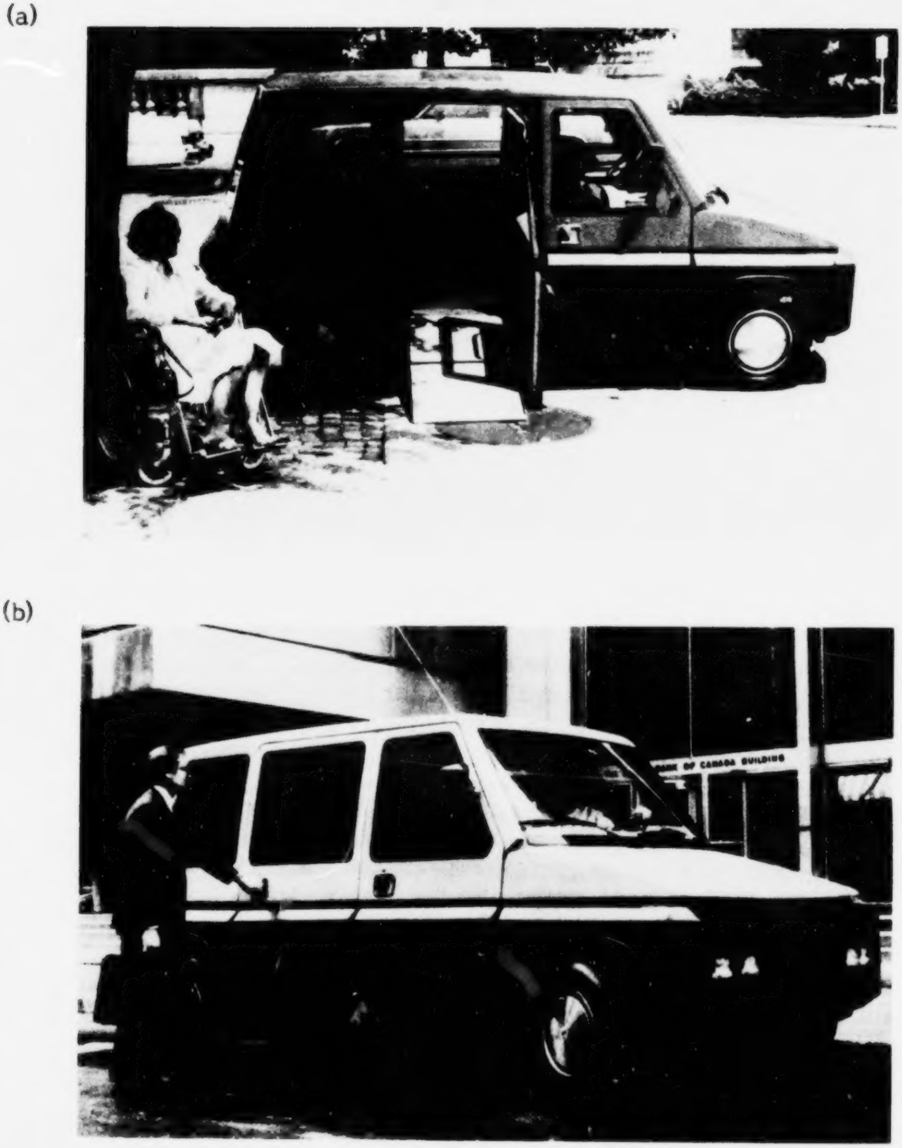
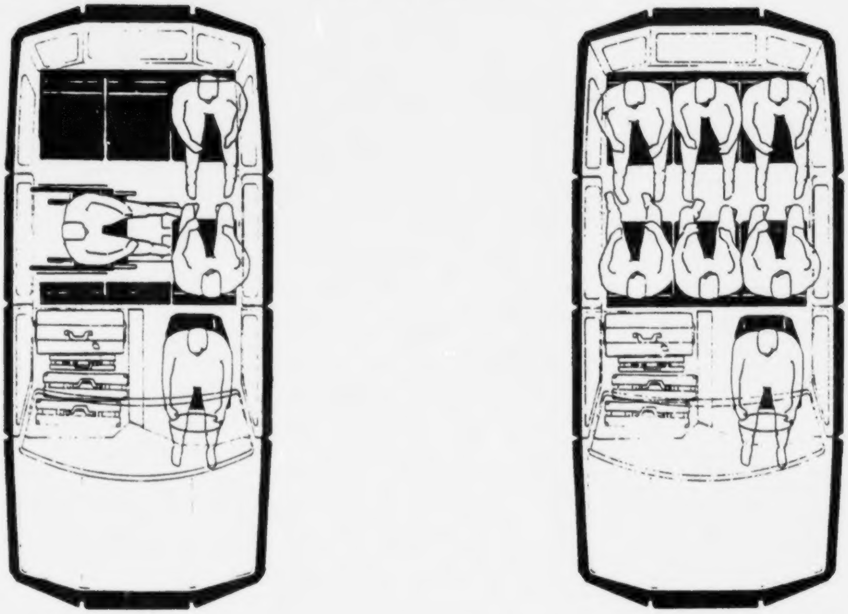


FIGURE 2.22
GSM TAXI INTERIOR LAYOUT



(a) Wheelchair Mode (b) Seated Mode

The perimeter bumper system (patented by GSM*), incorporates components which protect the body against impacts between 30.5 and 86.4 cm above ground level, utilizing urethane fabricated by the RIM (resin injection moulding) method. The front of the vehicle is protected by a central bumper plus two corner segments. The fenders are made of the same material and a common design accommodates all four fenders. Similarly, a common module is used for each of the four doors. The rear of the vehicle is fitted with a bumper system identical to the front, so that only four moulds are required to make a total of fourteen components used in the perimeter bumper system. As shown in Figure 2.23, the floor and seat areas are moulded in one piece of reinforced fibreglass. Above the bumper line, a moulded fibreglass upper body section is bolted to a rigid frame, accommodating the front and rear windows.

The front hood is a one-piece fibreglass section which opens up to expose the entire engine compartment for easy access and service. The upper section of the body, above the perimeter bumper, is painted with a high gloss automotive finish. The seats, which are easily removable, are covered with heavy-duty vinyl.

* Registered 1982, Guillon, Smith, Marquart Ltee. No. 49437 and U.S. Pat. D260627.

TABLE 2.5

GSM TAXI SPECIFICATIONS

GSM TAXI -	PHASE I FUNCTIONAL MODEL FRONT ENGINE (GAS OR DIESEL), REAR WHEEL DRIVE
Constructor:	GSM Taxi Ltd. 317 Place d'Youville, Montreal, Quebec H2Y 2B5
GENERAL	
Curb weight, kg	1500 (est.)
Weight distribution, front/rear %	54/46 (est.)
Wheelbase, m	2.81
Track, front/rear, m	1.65/1.65
Length, m	4.32
Width, m	1.91
Height, m	1.91
Ground clearance, m	0.18
Overhang, front/rear, m	0.81/0.81
Usable trunk space, m^3	0.71
Fuel capacity, litres	95.5
Bumper height, m	0.41-0.51
Headlight centre, height, m	0.64
Tail light cluster centre, height, m	0.64
Sidemarker lamps, height, m	0.94
Reflex reflectors, height, m	0.94
ENGINE	
Type	internal combustion engine 6 cyl. (gasoline, propane, natural gas), 4 cyl. diesel
Displacement, cm^3	4097
Brake horse power @ rpm net	100 @ 3600
Torque @ rpm, joules	237 @ 2000
Carburation	1 Rochester MV
Fuel requirement	Regular unleaded
Exhaust system	Single aluminized
Emission control equipment	Catalytic converter
DRIVETRAIN	
Transmission	GM 400 automatic
Final drive ratio	3.4:1
CHASSIS & BODY	
Layout	Front engine/rear drive
Body/frame	Semi-monocoque - steel rails & reinforced fiberglass body
Brake system	318 mm diam. discs front 283 mm x 70 mm drums rear (vaccum assis.)
Tires	Bias H 78-15/radial 2.25-15
Wheels	380 mm x 171 mm
Steering	Power assisted: recirculating ball gear parallelogram linkage
Front suspension	Independant coil springs, upper & lower 'A' - arms, anti-roll bar, 25 mm diam. tube shocks

Source: Adapted from Reference 4

Table 2.5 continued

GSM TAXI - PHASE I FUNCTIONAL MODEL
FRONT ENGINE (GAS OR DIESEL), REAR WHEEL DRIVE

Rear suspension	Salisbury axle, hypoid drive, coil springs, 4 outboard upper & lower control arms, 25 mm diam. shocks

INSTRUMENTATION

180 km/h speedometer, 99,999.0 km odometer, 999.9 km trip odometer, oil pressure, coolant temperature, ammeter, fuel level, oil pressure.

Warning lights: brake system, parking brake, alternator, coolant temp. fuel level, seat belt, headlights, high beam, directionals.

Air conditioning, taxi charge meter, AM/FM cassette stereo, 2-way radio and clock are optional.

ACCOMMODATION

Seating capacity	1 driver 6 passengers (3 & 3 occasional)
Seat width, front/rear, m	0.56/1.40
Headroom front/rear, m	1.02/1.02

FUEL ECONOMY - GAS (estimated)

26 - 20.5 L/100 km (11 - 14 mpg) City
18 - 13.0 L/100 km (16 - 22 mpg) Highway

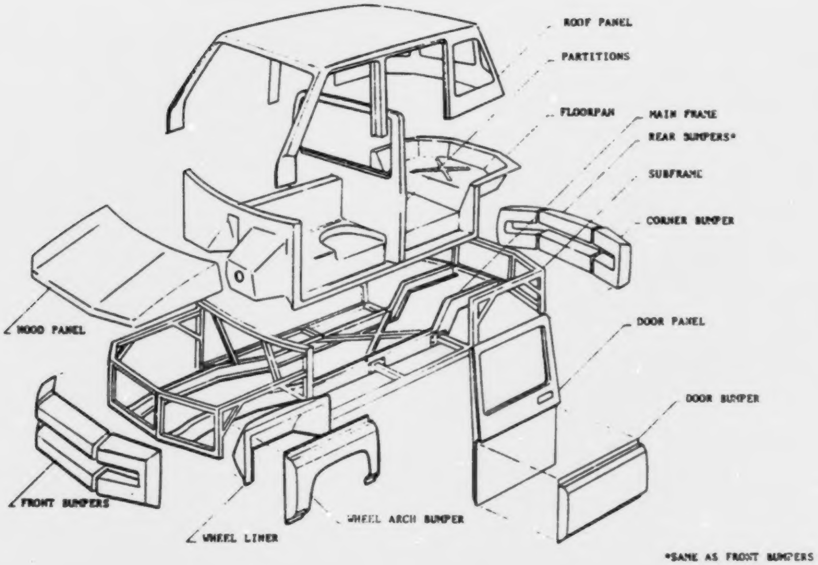
FUEL ECONOMY - DIESEL (estimated)

13 - 10.0 L/100 km (22 - 28 mpg) City
9 - 6.5 L/100 km (32 - 44 mpg) Highway

Source: Reference 4

Door panels, division panels, and kick-rails are covered in a carpet-like material that will withstand repeated scuffing and resist soiling. There is a partition between the driver and the passengers for privacy and security. The driver has electric door lock controls to control entry and exit from the passenger area and separate controls are used for the heating and ventilation of the passenger and driver compartments to ensure comfort in both areas. Luggage is stored next to the driver on the curb side of the vehicle for easy and safe access by the passenger and the driver. Two rearward facing jump-seats are fitted to the front of the passenger compartment for additional capacity. The driver's seat has a high back, minimizing driver fatigue during long periods on duty. The height of the vehicle improves driver and passenger visibility, making for safer, and more effortless trips. The braking system is heavy duty to withstand the severe duty cycle of taxi operations. The engine compartment is sufficiently large to accommodate a number of different engine options, including a front wheel drive configuration.

FIGURE 2.23
GSM TAXI MAJOR COMPONENTS



Source: Reference 4

The design concept of the GSM taxi is such that a "stretching" of the basic vehicle into six and eight door versions is feasible, with wheelbases of 372.1 cm and 614.7 cm respectively in comparison with the 255.3 cm wheelbase of the 4-door version. Figure 2.24 indicates the six door stretched version, the interior layout of which is shown in Figure 2.25.

The GSM taxi has a demonstrable capability to load and off-load wheelchairs with a removable ramp system which is stowed in the luggage space beside the driver. In spite of the high floor level of the vehicle, and the necessity to deploy and stow the ramp manually, it does have capabilities useful in the transport of the elderly and handicapped. The single wheelchair is restrained to the floor of the vehicle by a GSM designed mechanical restraint system, with the wheelchair in the lateral position, facing the roadside of the vehicle.

The anticipated retail price of the vehicle, at a rate of 5000 units per year is estimated at $20,000 (1981 dollars).

FIGURE 2.24
GSM TAXI - SIX DOOR VERSION

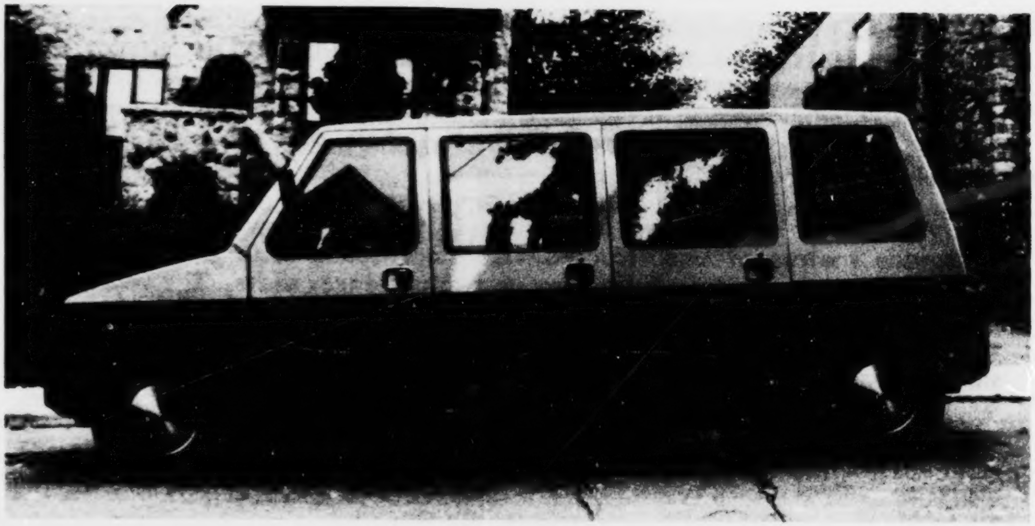
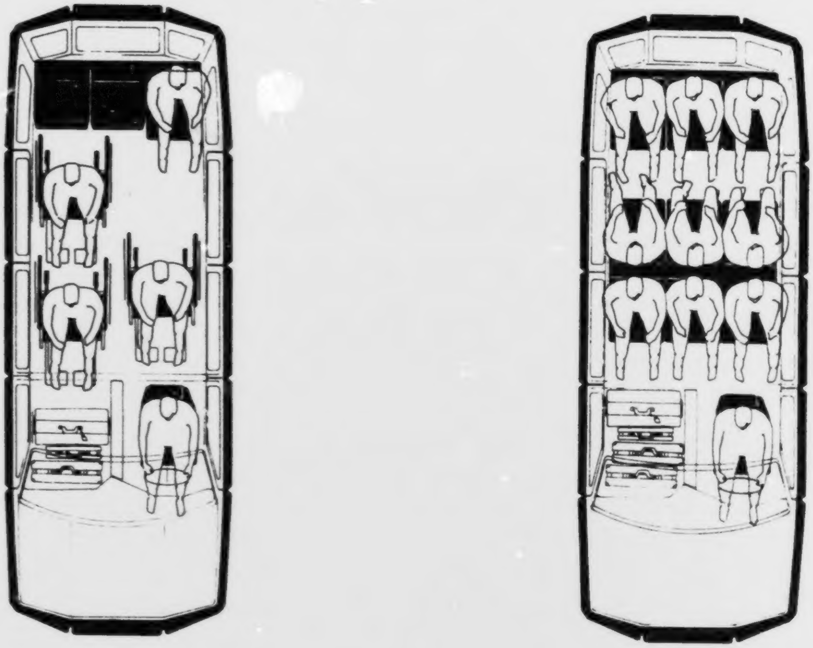


FIGURE 2.25
GSM TAXI - SIX DOOR VERSION, INTERIOR LAYOUT



(a) Wheelchair Mode

(b) Seated Mode

2.3.2 The McFarland Design Paratransit Vehicle

This vehicle is the result of a U.S. Department of Transportation project, funded and administered by the Urban Mass Transit Association (UMTA). McFarland Design of Santa Barbara, California, completed the construction of the prototype vehicle shown in Figure 2.26(a) and (b). The purpose built taxi cab is a vanlike low-floor vehicle with provisions for accommodating the elderly and handicapped. It has a seating capacity, in addition to the driver, of six passengers, or 4 passengers plus a wheelchair, or 2 passengers plus two wheelchairs, (See Figure 2.27).

The vehicle is also designed to operate in the delivery van mode, wherein 2.3 square metres of unobstructed flat floor space with a 453 kg cargo capacity is made available by folding up two passenger seats. The vehicle has three doors; a single driver's door and passenger door on the road side of the vehicle, and a large curb side door operated from the driver's seat. The curb side door is available as either a split door or a large single door. A powered wheelchair ramp is deployed from beneath the curb side door for loading wheelchairs. The wheelchair ramp extends only 71.1 cm from the side of the vehicle and provides a 12:1 slope down to a 15 cm curb. To achieve the short ramp, the vehicle body is lowered to a kneeling configuration by reducing the air suspension height on the rear axle by 7.6 cm.

A luggage compartment is situated alongside the driver, immediately inside the curb side door. Seating for six passengers is provided by a four seat rear unit and a rearward-facing two seat fold-down unit. The centre section of the rear seat folds up to accommodate a wheelchair. The floor of the driver's compartment is raised 12.7 cm above the passenger compartment to provide excellent driving visibility over a relatively short hood.

The vehicle power train is the General Motor's X-body front-wheel drive available with three engine options, the Pontiac L4 cylinder gasoline engine, the Chevrolet V6 gasoline engine and the GM 4-cylinder diesel engine proposed for the 1983 model year. A 4.6 litre V 6 diesel engine developed for the 1982 Oldsmobile Cierra may also be available. The front suspension is an integral part of the X-body front end including engine frame, power train and McPherson strut suspension. The coil springs and brakes are modified to accommodate the higher front loading and more demanding duty cycle experienced in paratransit service. The rear suspension is a modified X-body transverse axle with trailing arms, integral roll stabilizing bar, transverse rod and height controlled rolling sleeve airsprings. By means of an air valve control, the driver can raise or lower the rear vehicle height by 7.6 cm to accommodate the loading of wheelchairs. In addition the rear air suspension provides a level and comfortable ride regardless of load. The steering system is power assisted rack and pinion which is standard on GM X-body cars.

The vehicle construction is basically an aluminum body on a steel rail chassis, as shown in Figure 2.28.

The welded steel chassis assembly consists of two longitudinal beams extending from the firewall to the rear bumpers, separated by several transverse cross members. Stub frames form support and attachment points for the body. The firewall and structural support for the driveline and suspension are a welded sheet steel assembly. Welded steel structural members carry the primary loads from bumper-to-bumper. The driveline, suspension, and driver controls are mounted to the structural members and the formed aluminum body is fastened to the steel frame by means of insulated attachments to prevent galvanic corrosion.

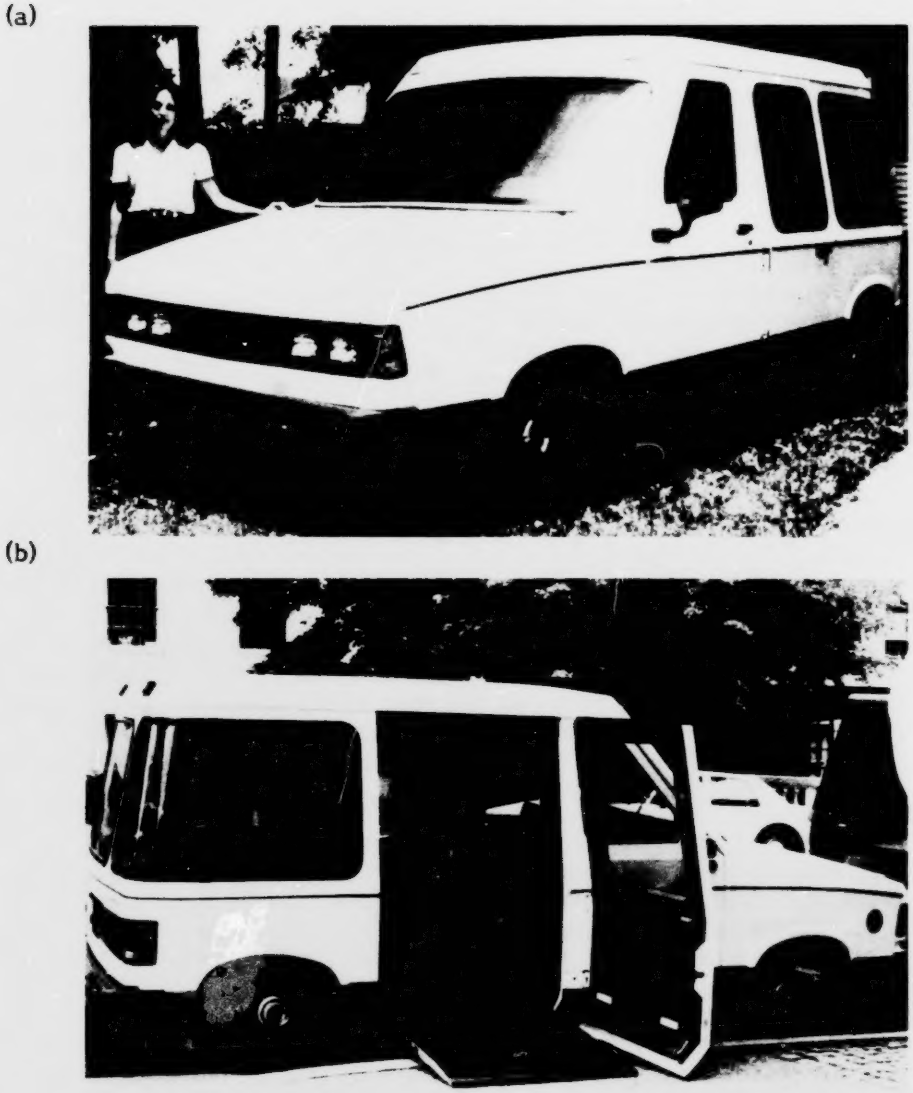
The body is an all aluminum structure consisting of extruded frames and sheet metal exterior panels. The structure is heli-arc welded and panels are attached by spotwelding. Front fenders, rear quarter panels and bumper valences are attached with removable fasteners. The doors and hood are also of aluminum construction. The roof is a one-piece rotational-moulded plastic cap overlapping a perimeter extruded rain gutter. The windshield is from a Ford Econoline Van, and 0.48 cm safety glass is utilized for the drivers and front curb side window with polycarbonate sheet being utilized for all other windows.

The combined frame and body produces torsional strength in excess of standard American automotive practice. Detailed specifications on the vehicle are given in Table 2.6.

For the transport of the elderly and handicapped, the vehicle is equipped with an automated ramp for wheelchair entry, sufficient room inside to manoeuver into a forward-facing position between the rear wheel-wells, and restraining means to secure the wheelchairs and occupants separately. In addition, vertical interior stanchions and handrails assist the elderly and handicapped to enter and leave the vehicle easily.

The estimated production cost of the vehicle, at a volume of 5000 units per year ranges from \$13,750 to \$14,650 (U.S. funds) depending upon the engine option selected.

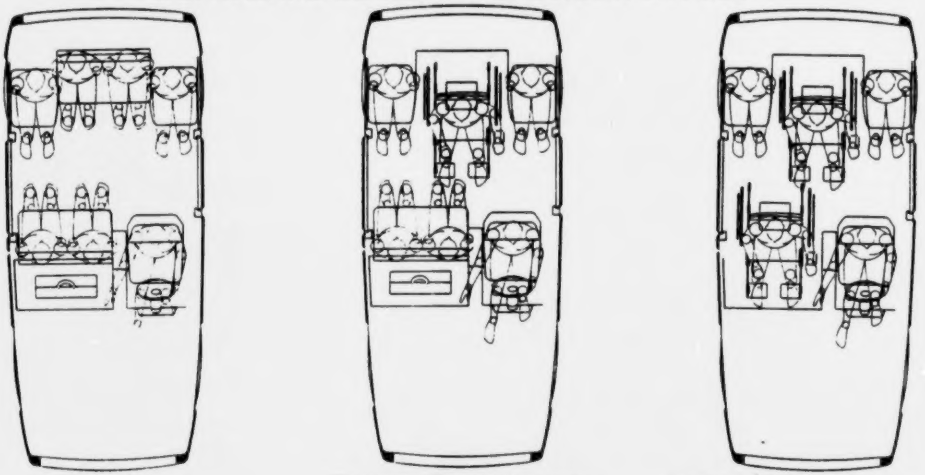
FIGURE 2.26
MCFARLAND DESIGN PARATRANSIT VEHICLE (PTV)



Source: Reference 5

FIGURE 2.27

MCFARLAND DESIGN PTV INTERIOR LAYOUT



Six passenger taxicab

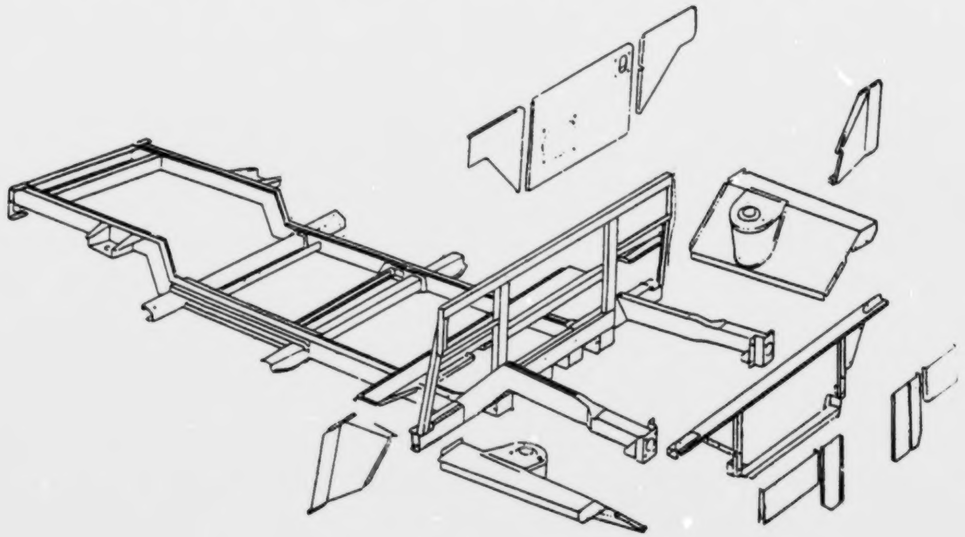
Five passenger PTV including one wheelchair

Four passenger PTV including two wheelchairs

Source: Reference 5

FIGURE 2.28

MCFARLAND DESIGN PTV CHASSIS AND FRONT STRUCTURE



Source: Reference 5

TABLE 2.6

MCFARLAND DESIGN PTV SPECIFICATIONS

General Specifications		
Powertrain	Front transverse mounted engine driving front wheels through automatic transaxle.	
Engine	L4	V6
Type	Gas	Gas
Valves	overhead with hydraulic lifters pushrods and rocker arms.	
Displacement	2474 cm^3	2835 cm^3
Cylinder Bore	10.2 cm	8.9 cm
Piston Stroke	7.6 cm	7.6 cm
Compression Ratio	8.2:1	8.5:1
SAE Net Torque (2400 RPM)	176 joules	190 joules
Fuel Metering	2 barrel carburetor	
Engine Dry Mass	157 kg	146 kg
Emission Certification	50 States	
Transmission	GM Automatic (3 speed) with Torque Converter	
Cooling System	8.04 L	9.94 L
Engine Oil	2.84 L	3.79 L
Fuel	2.84 L	3.79 L
Battery	12 volt, 120 Min. Reserve	
Alternator	12 volt/70 amp output	
Front Suspension	GM X-Body, McPherson strut and roll stabilizer	
Rear Suspension	GM X-Body, width modified, roll stabilizer, transverse rod, Firestone height controlled rolling sleeve airsprings	
Steering	GM X-Body, power assist rack and pinion	
Wheels	13 x 5.5 JB steel	
Tires	P-205R13 steel belted radials 615 kg load rating @ 241 kilopascals	
Body	Extruded aluminum structure, welded, stamped aluminum exterior panels welded or bolted	

Source: Adapted from Reference 5

Table 2.6 continued

Chassis	Rolled steel ladder type frame, welded, with steel sheet structure forward of firewall		
Seating	Driver plus 4 forward facing and 2 rear facing passengers or Driver plus 2 forward facing and 2 rear facing plus 1 wheelchair passenger		
Restraints	Driver - Class II inertia reel		
	Passengers - Class I autolock reel		
	Wheelchair - Class I autolock reel		
Dimensions			
Overall Length	4.62 m		
Overall Width	1.93 m		
Overall Height	1.93 m		
Ground Clearance	0.16 m @ chassis		
	0.15 m @ rear axle		
	0.16 m @ engine		
Floor Height	0.33 m @ ride level		
	0.25 m kneeled at curb		
Bumper Height	0.46 m		
Entry Step Height	0.15 m @ ride level from curb		
	0.30 m @ ride level from street		
	0.07 m kneeled from curb		
	0.22 m kneeled from street		
Wheelbase	2.84 m		
Track	1.60 m (rear)		
	1.49 m (front)		
Overhang	0.97 m (front)		
	0.81 m (rear)		
Approach Angle	22°		
Departure Angle	27°		
Ramp Over Angle	12°		
Entry Door Height	1.45 m		
Entry Door Width	0.91 m		
Interior Height (Headroom)	1.57 m		
Ramp Projection	0.71 m		
Ramp Width	0.89 m		
Ramp Angle to Curb	12:1		
Ramp Angle to Street	4:1		
Weight and Distribution			
Curb Weight	1430 kg.		
Payload	522 kg.		
Gross Vehicle Weight	1952 kg.		
Front Axle Load @ GVW	1001 kg.		
Rear Axle Load @ GVW	951 kg.		
Performance	Pontiac L4	Chevrolet V6	Isuzu Diesel C223
Acceleration (0-40 mph)	8.7 secs	7.7 secs	10.0 secs
EPA Urban Fuel Test	13.4 L/100 km	15.2 L/100 km	8.71 L/100 km
Turning Radius	13.4 m		

Source: Reference 5

2.3.3 The Minicar's Paratransit Vehicle

This vehicle was funded by the same UMTA project as the vehicle described in 2.3.2. Minicars Inc. of Goleta, California, built a total of four prototype vehicles, as shown in Figure 2.29(a) and (b) under the UMTA contract. The Minicar vehicle is based upon the principle of modifying a commercially available compact passenger car, rather than designing a new purpose-built vehicle. This approach was chosen, in order that the resulting vehicle would have the following positive attributes:

(i) It would have a known model life.

(ii) The essentials of the design would be applicable to other manufacturers of similar vehicles.

(iii) It would incorporate the new engineering features and performance required by national energy and safety regulations.

Minicars chose the four-door 1980 Oldsmobile Omega by General Motors as the most desirable base vehicle for modification. The major area of modification was to increase the height and length of the passenger compartment by stretching the body, raising the roof, providing a flat floor, reconfiguring the right rear door and sill, and widening the left B-post panel. The vehicle is essentially unchanged forward of its B-post and aft of its C-post. The wheelbase of the vehicle was increased from 266.4 cm to 327.6 cm, and the height from 131.8 cm to 177.8 cm at curb weight. The vehicle is readily converted by the driver into one of three service versions:

(i) Version 'A' - A conventional taxi layout for four passengers plus a driver. (See Figure 2.30)

Three passengers are seated in the rear seat, and one alongside the driver. The rear seat passenger's entry and egress is greatly facilitated by the additional headroom and large curb-side door. Luggage space is provided in the vehicle trunk and in a small parcel shelf over the drivers compartment. The large curbside door and adequate headroom provide good entrance and egress for the ambulatory elderly and handicapped. Each side of the curbside door is fitted with large handgrips for assisting the elderly and handicapped. Provision is also made for a security partition between the front and rear compartments.

(ii) Version 'B' - Taxi layout for three passengers, one in a wheelchair, plus the driver, (See Figure 2.31)

One ambulatory passenger shares the rear compartment with the wheelchair passenger, and the other passenger is located in the front seat with the driver. Wheelchair passenger loading is controlled by the driver, who remotely opens the right door and deploys a section of the door sill to which the wheelchair ramp is attached. The ramp angle is 12:1 when the vehicle is parked adjacent to a 15 cm curb.

The passenger in the wheelchair propels the wheelchair up the ramp into the vehicle and locates the chair facing forward against the rear bulkhead. The driver when secures the wheelchair in place by actuating a remote wheelchair restraint system.

(iii) Version 'C' - Cargo Layout for carrying up to 453 kg of packages in addition to the driver. (See Figure 2.32)

The maximum cargo volume is approximately 1.98 cubic metres in the rear passenger compartment with additional capacity in the trunk and storage area above the driver compartment. Cargo tie-down tracks are provided in the rear compartment.

All three versions are available with the 2.5 litre 4-cylinder GM engine, with the 2.8 litre V-6 engine as an option. In addition the 2.4 litre 4-cylinder Mercedes Benz diesel engine is offered, with the 4.6 litre V-6 GM diesel, offered in 1982, as the preferred diesel engine option.

The main structural modifications to the vehicle, are as follows:

- a flat passenger compartment floor was provided.
- the roof was raised to allow sufficient headroom.
- the curb-side door was enlarged, and a suitable retractable wheelchair ramp was installed.

The curb side door and ramp are remotely operated through a pair of electric linear actuators controlled from the driver's position.

A novel wheelchair passenger restraint system has been fitted to the vehicle, which is easy for the wheelchair passenger to deploy and store, and provides good protection in frontal collisions up to 50 km/h.

The Minicars PTV exceeded the normal curb weight of the Omega by 118 kg, and at maximum load it exceeds the Omega's rating by 226.5 kg. The spring rates of the suspension were duly modified, and structural reinforcements were fitted to the suspension attachment points. Detailed specifications of the vehicle are given in Table 2.7

The estimated purchase price of the Minicars vehicle, based upon an annual volume of 5000 vehicles, was $14,221 (U.S. funds) in 1979 dollars.

FIGURE 2.29
MINICARS PARATRANSIT VEHICLE

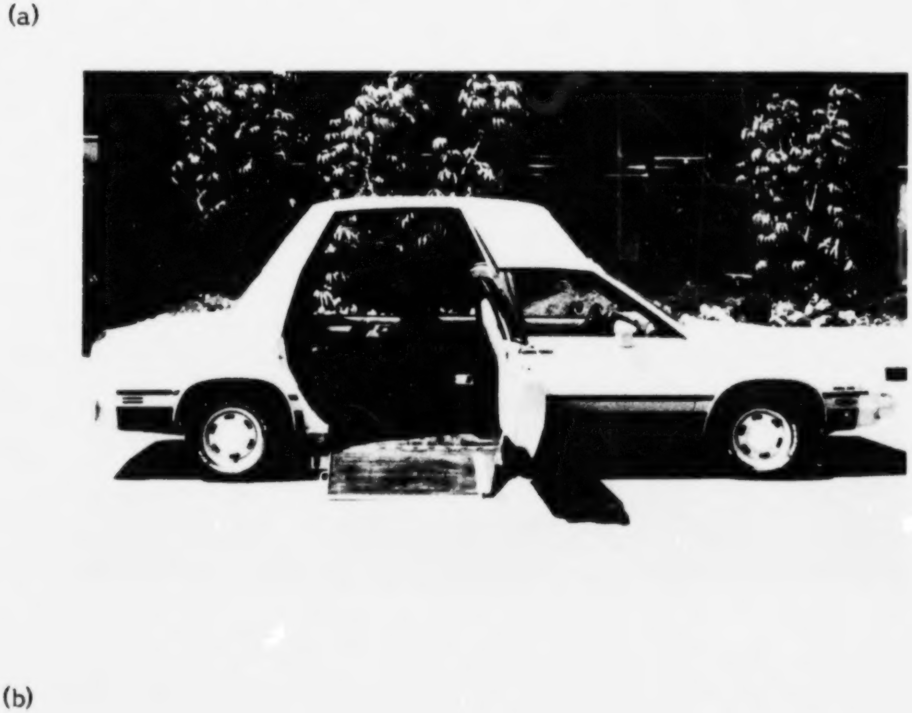


TABLE 2.7
MINICARS PTV DESIGN & PERFORMANCE SPECIFICATIONS

GENERAL	
Body type	Paratransit 4-door sedan
Curb weight	1410 kg
Weight distribution, F/R	58/42
CAPACITY (C.1)	
Version A (C.1.1)	Driver, four passengers, and 45 kg of cargo in a minimum of 425 cu. dm of cargo space. Consideration shall be given to permit use by elderly and ambulatory handicapped passengers.
Version B (C.1.2)	Driver, three passengers, one of them in a wheelchair and Version A cargo capacity.
Version C (C.1.3)	Driver only and 454 kg of cargo.
VEHICLE SIZE (C.2)	
Wheel base	3277 mm
Track, F/R	1491/1448 mm
Length (C.2.3)	5232 mm max.
Width (C.2.2)	1930 mm max.
Height (C.2.1)	1778 mm max. @ curb weight
Ground clearance	140 mm @ design load weight
Overhang, F/R	933/1021 mm max.
Fuel capacity	56.8 L
CHASSIS & BODY	
Layout	Front engine/front drive
Body/frame	Unitized
Front system (C.6)	
Front (C.6.2)	247 mm diameter vented disc
Rear	200 mm diameter drum
Power assist (C.6.1)	Vacuum
Swept area	1774 sq. mm
Wheels	13 x 5 pressed steel
Tires	P205/70R13
Steering type (C.14.4)	Power assisted rack and pinion
Turns lock to lock	3.1
Turning circle curb to curb (C.8)	14.5 m diameter
Front suspension	McPherson struts, coil springs, independent
Rear suspension	Trailing arms with integral rigid axle, coil springs

Engine (C.3)	Spark ignition (C.3.1)	Diesel (C.3.1)
Type	SOHC, in-line 4 cylinder	Mercedes-Benz 62 hp 2.4 litre 4 cylinder engine selected for prototype PTV.
Manufacturer	General Motors	
Displacement	2474 cc	
Bore x stroke	101.6 x 76.2 mm	General Motors V-6 engine tentatively selected for production PTVs.
BHP @ rpm, net	90 @ 4,000	
Torque @ rpm	135 @ 2,400	
Carburetion	Rochester 2 barrel	
Fuel requirement	91 RON, unleaded	
Emission control	Catalytic converter	
Availability (C.3.2)	Commercially available or scheduled for production	
Drivetrain (C.3)		
Transmission (C.3.3)	Automatic 3-speed with torque converter	
Gear ration:		
1st	2.84	
2nd	1.60	
3rd	1.00	
Overall axle ratio	2.53	
PERFORMANCE SPECIFICATIONS		
Acceleration (C.4)	Gasoline	Diesel
0.65 km/h @ CW	8 secs	11 secs
Fuel Economy (C.5)	Gasoline	Diesel
EPA Urban	13.8 L/100 km	11.2 L/100 km
Handling		
Lateral acceleration 100 ft. radius	0.6 G	
Speed through 213 m slalom 30.5 m pylon spacing	72 km/h	
Braking		
Minimum stopping distance from 60 mph	61 m	
Pedal effort for 0.5 G stop	16 kg	
Fade: percent increase in pedal effort to maintain 0.5 G deceleration in 6 stops from 60 mph	20	
Interior Noise		
Idle in neutral	61 dB A	
Full throttle acceleration	90 dB A	
Constant 30 mph	65 dB A	

Source: Adapted from Reference 7

FIGURE 2.30
MINICARS PTV VERSION 'A' OCCUPANT PACKAGING

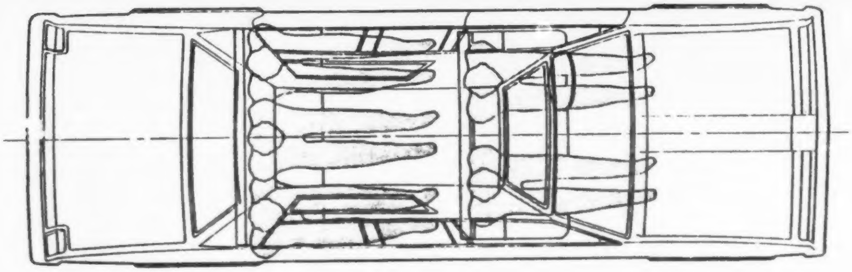


FIGURE 2.31
MINICARS PTV VERSION 'B' OCCUPANT PACKAGING

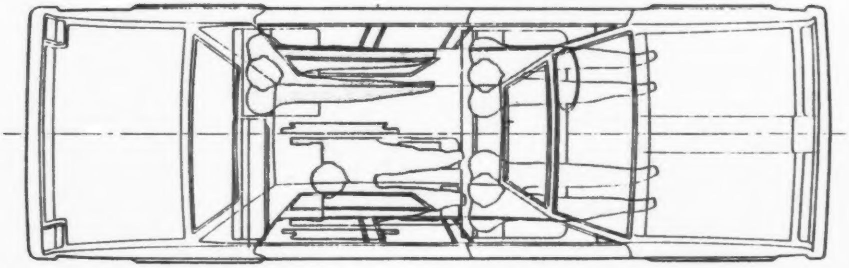
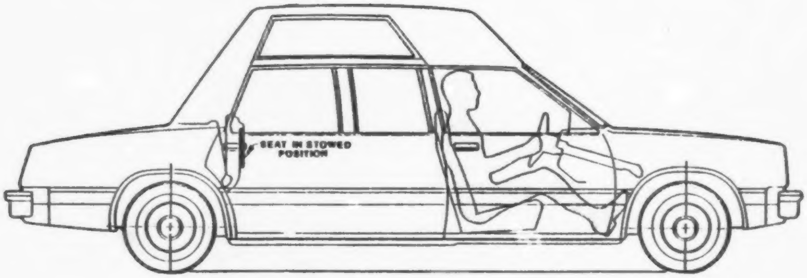


FIGURE 2.32
MINICARS PTV VERSION 'C' OCCUPANT PACKAGING



Source: Reference 6

2.3.4 Dutcher Industries Vehicles (TDT/Dutcher Industries)

This firm has been involved in the field of paratransit vehicles since 1974, when, operating as Steam Power Systems Inc., it was awarded a U.S. D.O.T. contract to construct a prototype steam powered paratransit vehicle. The vehicle was completed in June 1976, and was further modified to accept a conventional internal combustion engine in 1976. The vehicle underwent extensive testing and user evaluation. Subsequently the firm was awarded a contract to carry out a design study on a low cost paratransit vehicle. The study was completed in 1978 and the firm is now involved in a multi-phase program which will culminate in the development of a prototype vehicle, in accordance with the designs developed in the life cycle cost study. The first generation Dutcher vehicle is illustrated in Figure 2.33(a).

Figure 2.33(b) is an illustration of the vehicle design concept; the vehicle is van-like, incorporating seating for seven passengers in addition to the driver. Optional configuration includes the following capacities:

- one forward-facing wheelchair plus four passengers
- two rearward-facing wheelchairs plus five seated passengers
- 475 kg of cargo

Figure 2.34 indicates the seating configuration including one wheelchair.

The vehicle is of rear-engine, rear drive configuration, with a low flat floor in the passenger compartment. The frame of the vehicle utilizes a welded steel space-frame primary structure (see Figure 2.35)

Fibreglass reinforced plastic (FRP) exterior body panels are attached to the space frame to complete the exterior of the body. Those panels subject to collision damage (fenders, doors, front and rear hoods) are easily replaceable. The remainder of the panels are permanently bonded to the space-frame and contribute to the rigidity of the chassis. The result is a relatively lightweight structure with excellent rigidity and repairability.

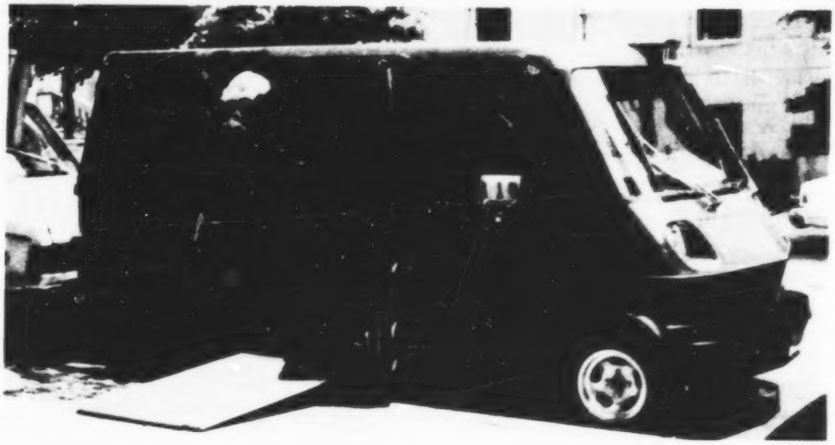
The vehicle is designed with a manually deployed ramp system for loading wheelchair passengers. The system uses extruded aluminum ramp sections which are stored inside the vehicle. An optional fully automatic driver-operated ramp system will also be available. The passenger compartment doors are conventional one-piece hinged doors with a 101.6 cm opening. The standard power plant is a 2.3 litre Ford 4-cylinder engine (89 hp) coupled to a three-speed automatic transmission. Optional engines will include a turbo-charged 2.3 litre Ford 4-cylinder (130 hp) and a Peugeot 2.3 litre diesel (71 hp).

The front suspension and transmission utilized are from a Ford E100 van, and the rear suspension is from a Ford Bronco four-wheel drive vehicle, giving excellent durability in a taxi operation. The suspension is fully independent, front and rear, and truck disc brakes are fitted to give good performance and

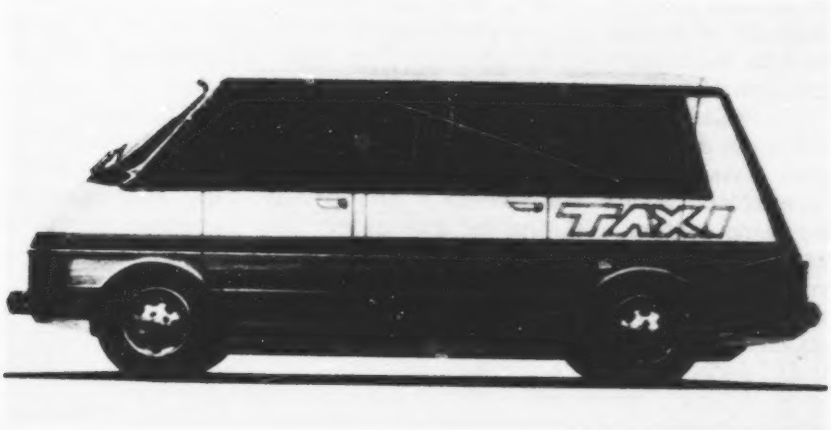
FIGURE 2.33

DUTCHER INDUSTRIES PARATRANSIT VEHICLE - DESIGN CONCEPT

(a) First Generation Vehicle



(b) Design Concept



durability. The combination of the rear mounted engine and the large rear hood provide excellent accessibility to the entire power train. The use of a non-driven steering axle eliminates the constant velocity universal joints which limit the steering angles in front wheel drive vehicles, leading to large turning circles. In addition to the rear wheel drive/rear engine configuration places all drive components behind the passenger compartment, permitting a low, flat, compartment floor.

Table 2.8 gives detailed specifications on the vehicle; which has an intended selling price of $20,000 (U.S. funds) in 1980 dollars, when produced at a rate of 5,000 units per year. The present program will require approximately fifteen months for the development of a prototype vehicle, and two years for the first production vehicles, including FMVSS Certification.

TABLE 2.8

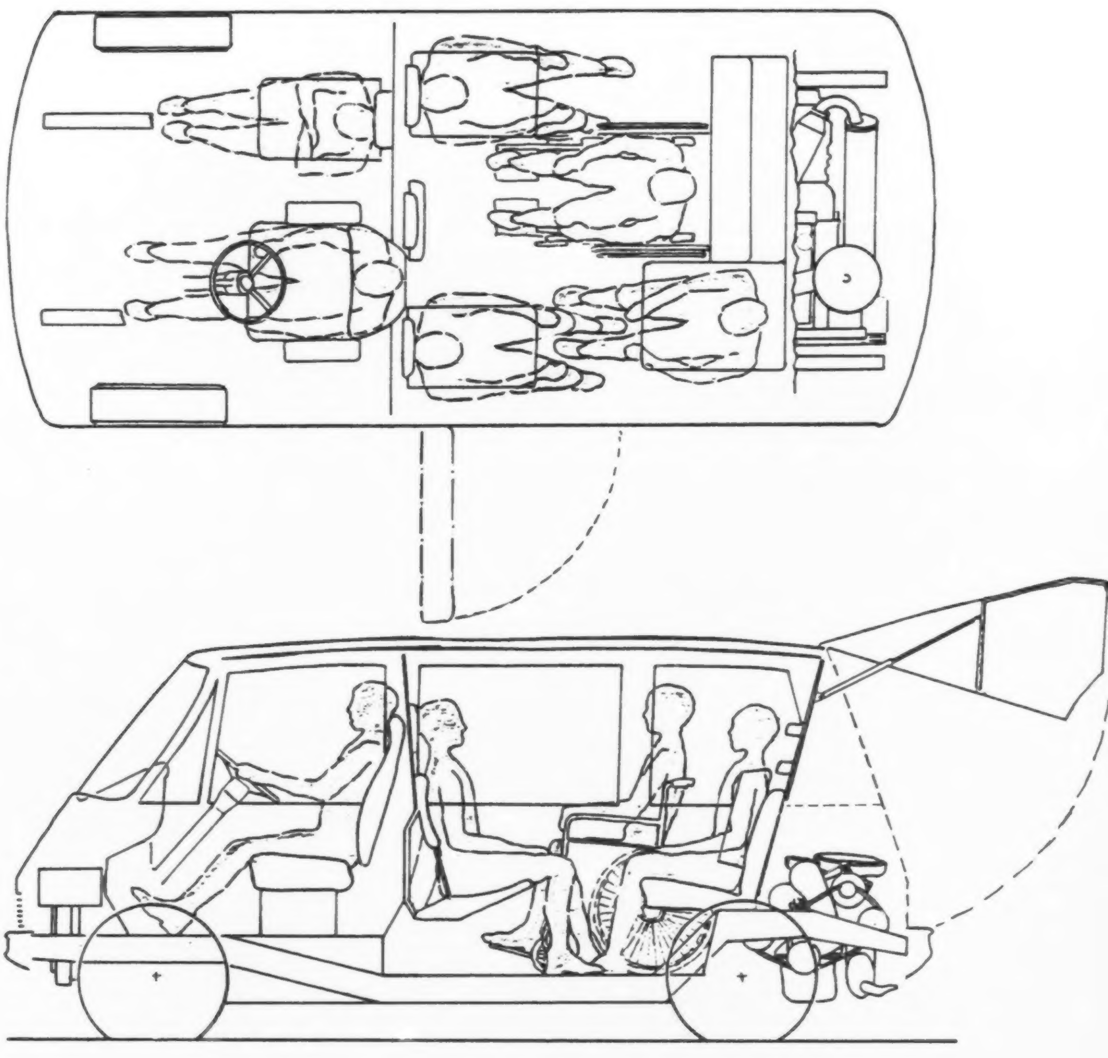
DUTCHER INDUSTRIES PARATRANSIT VEHICLE - SPECIFICATIONS

Vehicle Height	1.88 m
Vehicle Width	2.03 m
Vehicle Length	4.83 m
Wheelbase	2.87 m
Turning circle diameter	11.0 m
Ground to floor height	3.05 m
Wheelchair rampslope to 6" curb	12:1
Floor to roof height	1.52 m
Door opening width	1.02 m
Curb weight	1500 kg
Payload	544 kg
Maximum gvw	2087 kg
Top Speed	105 km/h
Acceleration	0-64 km/h in 9 seconds
Fuel Consumption	8.1 L/100 km
Engines:	
Standard - 2.3 litre Ford 4 cyl.	(89 hp)
Optional - 2.3 litre Ford 4 cyl. turbocharged	(89 hp) (130 hp)
Optional - 2.3 litre Peugeot diesel	(71 hp)
Transmission:	
3 speed automatic Ford C-4 with torque converter.	

Source: Adapted from Reference 8

FIGURE 2.34

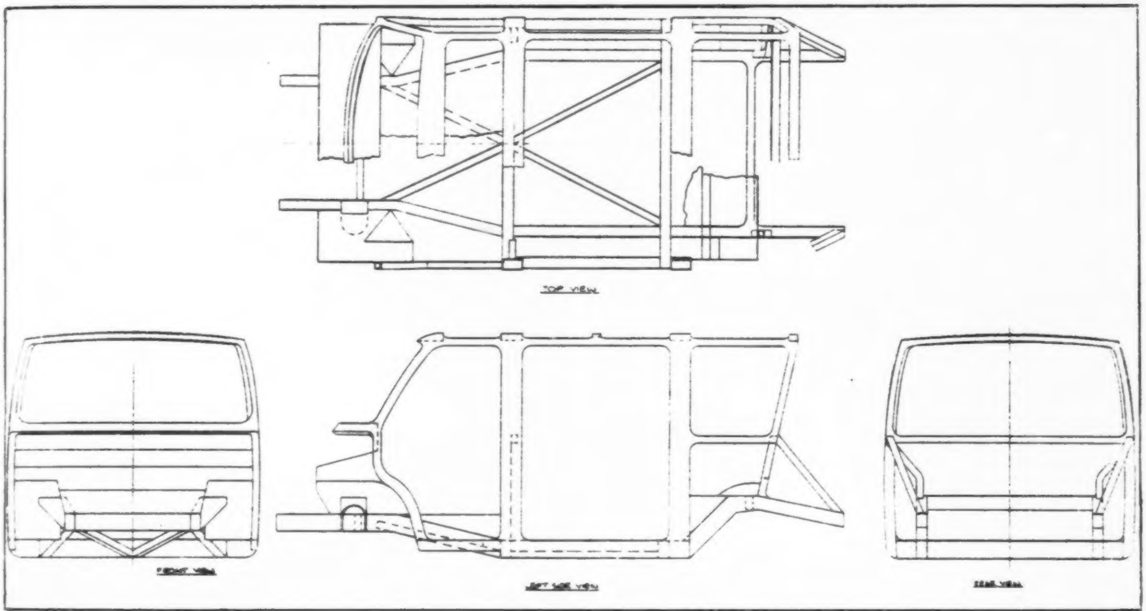
DUTCHER INDUSTRIES PARATRANSIT VEHICLE SEATING ARRANGEMENT WITH ONE WHEELCHAIR



Source: Reference 8

FIGURE 2.35

DUTCHER INDUSTRIES PARATRANSIT VEHICLE CHASSIS STRUCTURE CONCEPT

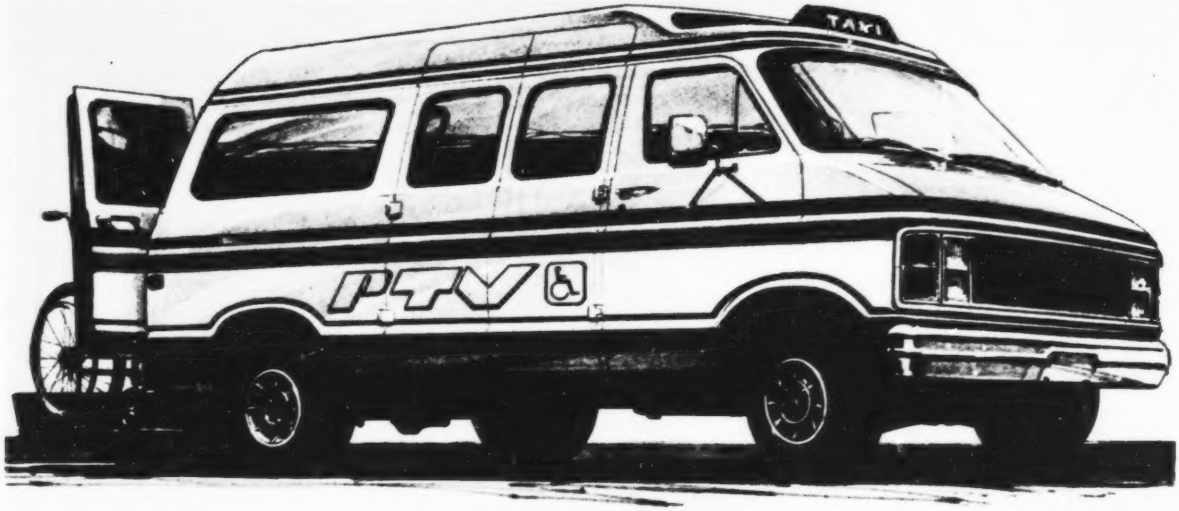


Source: Reference 8

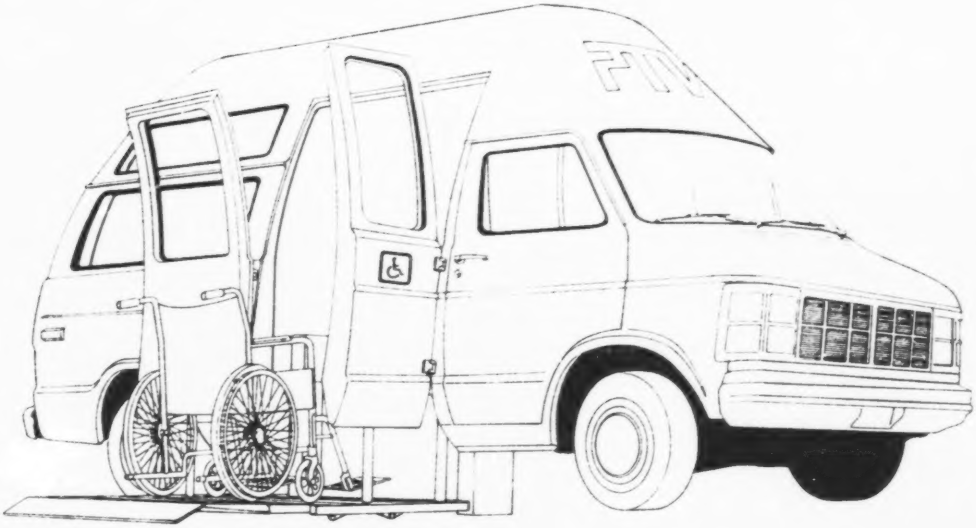
Dutcher Industries have also studied the merits of the conversion of a currently produced North American van and a foreign mini-van. Problems have been encountered with respect to the foreign van's ability to meet required safety standards, however the North American retrofit is being actively pursued. Currently the company is soliciting response from owner/operators in their attempts to further the state-of-the-art in urban vehicle design. Two variations of the vehicle are indicated on Figure 2.36. The upper figure, 2.36(a), shows the version with a rear mounted lift while in the lower figure, 2.36(b), the vehicle has a raised roof and side access for wheelchairs. The proposed vehicle specifications are indicated in Table 2.9.

FIGURE 2.36

DUTCHER INDUSTRIES RETROFIT - US VAN PTV



(a) Rear-Mounted Lift (and low roof)



(b) Side-Mounted Lift (and raised roof)

Source: Reference 8

TABLE 2.9
DUTCHER INDUSTRIES RETROFIT - US VAN PTV SPECIFICATIONS

SIZE

Length	5.00 m
Width	2.03 m
Height	2.34 m
Wheelbase	3.25 m
Ground Clearance	0.20 m
Curb Weight	1588 kg
Max Payload	1134 kg

ACCOMMODATIONS

Driver PLUS:

9 seated passengers
1 in wheelchair + 8 seated
2 in wheelchair + 7 seated
Any combination of passengers or cargo not exceeding 1134 kg total

EQUIPMENT

- Engines:

6 cyl	3.7 litre, 95 BHP
8 cyl	5.2 litre, 140 BHP

Diesel engine availability is expected soon

- Transmission:
  STD - 4 speed manual overdrive
  Optional - 3 speed automatic w/lockup torque converter
- Brakes:
  Disc front, drum rear
- Automatic step lift
- Double doors on both sides and rear
- Overhang storage rack

OPTIONS

- Bullet Resistant Driver Partition
- Roof Mounted Air Conditioning
- V-8 Engine
- Diesel Engine

Source: Adapted from Reference 8

2.3.5 Winnebago Industries Vehicles

Winnebago Industries Ltd, of Forest city, Iowa, was originally a subcontractor on developing production costs for the McFarland paratransit vehicle. Subsequently, Winnebago developed a family of paratransit vehicles on their own initiative, which they are presently planning on offering to the market.

The family of vehicles, illustrated on Figures 2.37 through 2.40 has the following basic characteristics:

Metro 3 - Capacity of five passengers of four passengers plus a wheelchair or 453 kg of cargo.

Metro 4 - Capacity of six passengers including 1 wheelchair facing forward or five passengers and four wheelchairs. An optional high roof version would provide a stand-up height inside.

Metro 5 - Capacity of six wheelchair passengers, facing forward.

Metro 6 - The largest Winnebago PTV with capability of accommodating large groups of wheelchair passengers.

Winnebago is currently concentrating on the Metro 3 which is a modified Renault TRAFFIC van, of front engine/front wheel drive configuration. This vehicle is not presently imported into North America and Winnebago has an exclusive agreement with Renault/American Motors for conversion of the vehicle. The list price premium for an optional diesel engine in lieu of the standard gasoline engine is $700 (U.S.). The seating arrangement includes three forward facing seats across the rear of the vehicle, one forward facing seat on the road side of the passenger compartment and one rearward facing passenger seat alongside the driver, plus a curb-facing wheelchair position in the middle of the passenger compartment. Wheelchair tie downs and passenger seatbelts are fitted for safety. Cargo space is available behind the three rear seats and is accessible through the two rear doors. The interior of the vehicle is finished with durable materials to ensure good maintainability in paratransit service.

The Metro 4 is designed around a 317.5 cm version of the Renault van while the Metro 5 is designed around a 337.8 cm wheelbase, rear wheel drive Chevrolet truck chassis. Table 2.10 presents detailed specifications for the Metro 3, 5 and 6.

Data on the Metro 4 is as follows:(1)

- 125" wheelbase.
- 5300 lb. gross vehicle weight.
- 2 litre Diesel.
- 4-speed manual transmission.
- Forward facing wheelchair accommodations.
- 6 additional passenger accommodations.
- Double side door.
- Mechanical ramp operated from driver's seat.
- Low standard roof line. (Same as Metro 3).

---

(1) Source: Reference 9

Options include:

- Removable co-pilot seat for luggage.
- Automatic ramp.
- Left-hand side door.
- High roof line for stand-up headroom and easy entrance.

Initial cost of the Metro 3 diesel in quantity 50 is projected at $21,000 (U.S. funds), in 1980 dollars, exclusive of tooling amortization. A lead-time of fifteen months is required. With tooling amortization included, the cost of the intitial vehicles would be $40,000 (U.S.), in 1980 dollars. At an annual production rate of 3,000 units, the cost of the diesel powered Metro 3 is estimated at $18,000 (U.S.), in 1980 dollars.

FIGURE 2.37
WINNEBAGO INDUSTRIES VEHICLE METRO 3

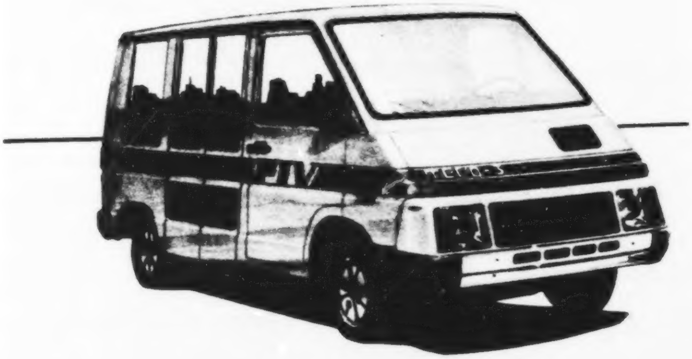


FIGURE 2.38
WINNEBAGO INDUSTRIES VEHICLE METRO 4

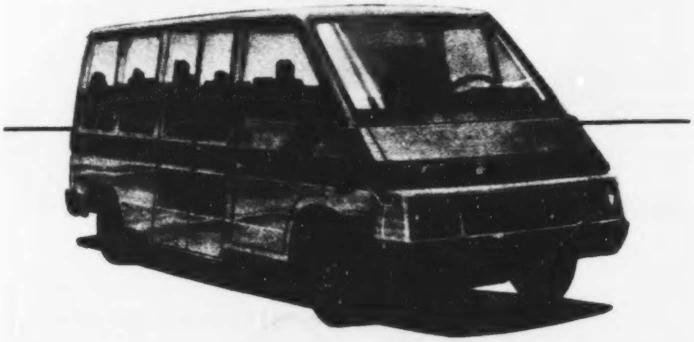


FIGURE 2.39

WINNEBAGO INDUSTRIES VEHICLE METRO 5

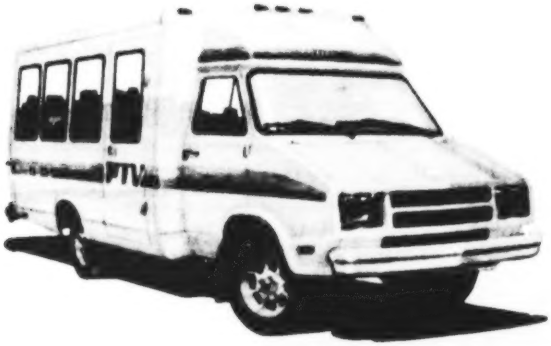


FIGURE 2.40

WINNEBAGO INDUSTRIES VEHICLE METRO 6

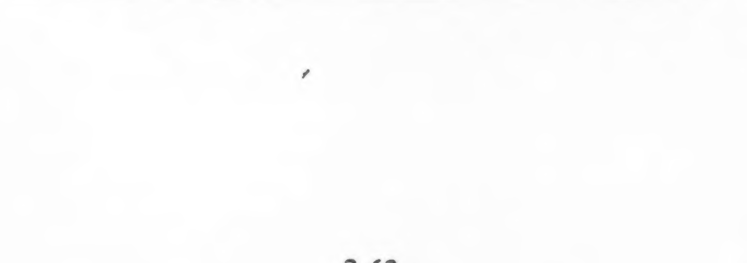


TABLE 2.10

WINNEBAGO SPECIFICATIONS - METRO 3, 5 AND 6

METRO 3	GAS	DIESEL
Engines	2.0 L	2.1 L
Wheelbase	2.80 m	2.80 m
Fuel	60 L	60 L
Tires	165SR-14	165R-14
Overall length	4.43 m	4.43 m
Overall width	1.91 m	1.91 m
Overall height	2.04 m	2.04 m
Interior width	1.65 m	1.65 m
Interior height	1.73 & 1.52 m	1.73 & 1.52 m
Ground clearance	0.14 m	0.14 m
Floor height	0.23 m	0.23 m
Bumper height	0.47 m	0.47 m
Front track	1.56 m	1.56 m
Rear track	1.52 m	1.52 m
Front overhang	0.88 m	0.88 m
Rear overhang	0.75 m	0.75 m
Transmission	4 speed manual	4 speed manual
Automatic transmission	available summer '83	
Battery		
Approach angle	27°	27°
Departure angle	28°	28°
Brake over angle	12°	12°
Front axle load	1200 kg	1200 kg
Rear axle load	1225 kg	1225 kg
Drive axle gear ratio	9/34	9/34
Horsepower	84 @ 5,000 rpm	59 @ 4,000 rpm
GVW	2400 kg	2400 kg
Load capacity:		
Standard Version A	5 passengers, 45 kg cargo	
Version B	1 wheelchair, 3 passengers, 45 kg cargo	
Version C	454 kg cargo	
Option	2 wheelchairs, 1 passenger	

METRO 5	GAS
Engine	Chevy 5.7 L
Wheelbase	3.38 m
Fuel	151 L
Tires	8.75R16.5LT
Overall length	6.99 m
Overall width	2.32 m
Overall height	2.71 m
Ground clearance	0.23 m
Transmission	3 speed automatic
Interior width	2.24 m
Interior height	1.91 m
Horsepower	165 @ 3,800 rpm
GVW	3,900 kg
Load capacity:	
Version A	6 wheelchairs, 1 passenger
Version B	4 wheelchairs, 5 passengers

METRO 6	GAS	DIESEL
Engine	2.0 L	2.1 L
Wheelbase	3.68 m	3.68 m
Fuel	60 L	60 L
Tires	185SR-14	185R-14
Overall length	5.96 m	5.96 m
Overall width	2.16 m	2.16 m
Overall height	2.13 m	2.13 m
Ground clearance	0.23 m	0.23 m
Transmission	4 speed manual	4 speed manual
Automatic transmission	Available spring '83	
Interior width	2.08 m	2.08 m
Interior height	1.72 m	1.72 m
Horsepower	84 @ 5,000 rpm	59 @ 4,000 rpm
GVW	2400 kg	2400 kg

Source: Adapted from Reference 10

2.4 Foreign Paratransit Vehicles

During the course of this project, data was collected on foreign vehicles having application in paratransit service. A brief synopsis of the data is presented herein. It should be noted that the vehicles are primarily from England and other European countries and are largely modified vans used to transport elderly or handicapped people. A significant amount of data was available on small buses and transit buses, but these vehicles are beyond the scope of this project. The relevant vehicles are described below:

2.4.1 Peugeot Nivo

This vehicle is a standard Peugeot Nivo van, converted for the transport of wheelchair passengers. It has the following dimensional characteristics:

- overall length	470.0 cm
- overall width	175.0 cm
- overall height	233.0 cm
- wheelbase	250.0 cm
- interior height	182.0 cm
- optional	214.0 cm
- door width	101.0 cm
- height of floor above road	50.8 cm

The vehicle is of front wheel drive configuration, with a flat rear floor and wheelchair loading is via the rear door using a ramp system and kneeling rear suspension (total movement is approximately 13 cm). The payload capacity of the vehicle is 5 wheelchairs.

2.4.2. Smulders Systems Vehicles

This firm, located in Eindhoven, the Netherlands, offers two converted vehicles for the transport of wheelchair passengers. The two base vehicles for modification are the Simca 1100 delivery van and the Talbot Matra Rancho. Both vehicles carry a single wheelchair plus driver and a maximum of three seated passengers. Wheelchair entry is by a rear door and short ramp. The kneeling rear suspension utilizes converted rear shock absorbers which act as hydraulic lift cylinders to raise and lower the rear of vehicle for loading/unloading. The side windows of the vehicle are modified to the eye level of the wheelchair passenger, and a wheelchair restraint system is fitted. The Simca 1100 vehicle has the following dimensions.

- overall length	400.0 cm
- overall width	158.8 cm
- overall height	191.0 cm
- ground clearance	14.0 cm
- wheelbase	252.0 cm
- inside height	154.0 cm

The Matra Rancho version has the following dimensions:

- overall length	431.5 cm
- overall width	166.5 cm
- overall height	178.0 cm
- ground clearance	17.0 cm
- wheelbase	252.0 cm
- inside height	145.0 cm

2.4.3 GKN Sankey Invalid Car and the Elswick Envoy

Both these English vehicles are designed specifically to be driven by disabled people who are confined to a wheelchair which can be locked in a central driving position. Both vehicles are intended primarily for personal use rather than commercial paratransit application and thus are beyond the scope of this study.

2.4.4 Prototype Vehicles in England

As part of the BP Build-a-Car Competition in England, Shrewsbury School and Broadland School built prototype vehicles for the handicapped named the Invashrew and the Broadland Wasp, respectively. The prototype vehicles have been tested subjectively, but further development and safety testing are required before the vehicles would be suitable for production.

Rootes Maidstone Ltd. offers various conversions of a British Leyland Mini Clubman Estate Car, which are capable of carrying a person in a wheelchair stationed behind the drivers seat. The wheelchair occupant is able to enter and exit the vehicle by means of a mechanically operated ramp fitted to the rear of the vehicle. Its operation is by means of an electric winch. The wheelchair occupant can transfer himself/herself from the wheelchair into the drivers seat and operate the vehicle via hand controls.

2.4.5 French Vehicles

An electric car, called the Handicar, has been developed by Teilhol Voiture Electrique in France. The rear suspension kneels to permit loading and unloading of the driver's wheelchair. The reported maximum speed and range of the vehicle are 50 km/h and 60 km respectively.

A Renault 4 has been modified by TREGIE to carry a wheelchair passenger along with three seated passengers.

2.5 Standard Vehicle Design Trends

2.5.1 Passenger Car

The full size passenger car, due to the legal requirements for greatly improved fuel economy, is under continued downsizing pressure. It is anticipated that the 1985, full size passenger car will be similar to the present GM four door, front wheel drive X-car. Vehicles of this size are of limited usefulness in taxi applications for the commercial transport of the elderly and handicapped.

2.5.2 Special Taxi Vehicle

In June 1981, Checker Motors announced the development of a fuel efficient downsized four door hatchback cab. Four models were planned, a 277 cm wheelbase 5 passenger model, a 312.4 cm wheelbase seven passenger model, a 325 cm wheelbase eight passenger model, and a 325 cm wheelbase paratransit model with a raised roof and a special door to accommodate wheelchairs and similar equipment.

Checker planned to produce the 277 cm wheelbase version in October 1982 as a 1983 model. However, Checker Motors in early 1982, cancelled their plans for expanding their line of vehicles.

The firm planned to continue producing its original line of large taxis as long as the components were available and there was a market demand for them, however, in April 1982 this plan was reevaluated and the company announced it would no longer be making its distinctive taxi vehicle.

Development work is currently being undertaken in England for a new taxi vehicle based on a Rover chassis. It is unlikely, however, that this vehicle will gain any significant market penetration in North America.

2.5.3 Standard Multi-Purpose Vehicle (MPV)

The North American van is undergoing a gradual downsizing process, and the introduction of foreign front wheel drive mini vans such as the Renault "Traffik" or the Mitsubishi van is anticipated. These trends will further limit the application of vans to paratransit work due to limited headroom, narrow aisles, limited seating, and more difficult entrance and egress, particularly for the elderly and handicapped.

2.5.4 Modified MPV

These vehicles will continue to play a role in paratransit service due to their relatively low initial cost. The required modifications may become somewhat more extensive with continued downsizing, but the ingenuity of the modification industry will likely overcome these problems, at least in the short term.

2.5.5 Body on Chassis

These vehicles normally add a custom body to a light truck cab-chassis or a complete body to a light truck chassis. As downsizing enters into the light truck industry, this class of vehicles will have to make the necessary adjustments and changes in its product line. Decreases in the payload capacity of the light truck chassis will require either a downsizing of the complete vehicle, or the development of a more suitable chassis.

2.6 Relationship Between Paratransit Operations and Vehicle Design

The key paratransit operational factors which impact the design of a paratransit vehicle are:

- The number of passengers carried, as this affects vehicle capacity/size.
- The type of passengers (conventional or elderly/handicapped) carried, as this affects interior configuration and means of entrance/egress.
- The duty cycle, as this defines the durability which must be designed into the vehicle, which impacts capital cost.
- The operating mode (demand responsive or fixed route), as this defines the ancilliary equipment requirements, ie. communications equipment.
- Comfort and security of both passengers and driver.
- Operating costs, as impacted by fuel, durability and maintenance.

Whether or not there is an optimum size for a paratransit vehicle is questionable. The 'best' size is very dependant upon the nature of a specific operation. It may not be feasible to design a paratransit vehicle capable of providing the complete range of paratransit services required. A family of vehicles of various sizes, such as that proposed by Winnebago may be more appropriate. A recent study (1) has proposed appropriate sizes for various paratransit vehicles:

Jitney vehicle: 6-12 passengers, with direct access to doors.

Dial-a-ride: 8 passengers, special purpose taxi or van.

Vehicle for handicapped: 4 passengers - 3 in back plus 1 in front.

The appropriate size of vehicle is often determined by the maximum amount of time that the first (and each succeeding) passenger can be expected to spend in getting to their destination. This includes loading and unloading time which ranges from fractions of a minute per passenger with jitneys to several minutes with handicapped vehicles.

---

(1) Reference 1

The requirement to carry elderly and handicapped passengers has a profound effect upon the design of paratransit vehicles, particularly in the area of entrance and egress, and internal size and configuration, related, in particular, to wheelchairs. Ramp and/or lift systems are required, along with low floor and entrance step heights, plus flat floors, and wheelchair restraint systems. For a given vehicle, the requirement to carry wheelchairs greatly reduces its total passenger capacity, due to the space required to manoeuver and restrain the wheelchairs. In addition, loading and unloading times become a significant portion of the total trip time. Severe trip routing restrictions are often imposed by the necessity to unload wheelchairs in the same sequence in which they were loaded, due to limited internal manoeuvering room in most paratransit vehicles.

2.7 Conclusions

Principally due to their low initial cost, standard passenger cars, vans, and modified vans find extensive application in paratransit service. These vehicles, not being designed for the continuous duty cycle of transit applications, frequently suffer from increased maintenance or reduced longevity, resulting in appreciably increased operating costs. The dimensions of converted vehicles, and the ease of access and egress, are commonly unsuited to passengers who are either in wheelchairs or are otherwise mobility disadvantaged.

There is a role for an unique purpose-designed paratransit vehicle, or family of vehicles. Until recently little attention has been paid to the design of these vehicles, due principally to the limited market (estimated at 5,000 to 10,000 vehicles per year in North America). This market volume is too small to interest the major manufacturers and too large to be covered by the small custom manufacturer. The continued downsizing trends in the family passenger car and van market may well limit the usefulness of these vehicles in paratransit operations, thereby giving rise to a new purpose-built paratransit vehicle. In order to permit such a vehicle to appear in the marketplace, great attention should be paid to the vehicle specifications and vehicle operating costs, longevity and other such factors. These points are addressed in Chapter 4 of this report, followed by (in Chapter 5) the presentation of guidelines for operators, designers and legislators.

3.0 LEGISLATION

3.1 Existing Canadian Legislation

The current legislation affecting the provision of taxi and paratransit services is provided by all three levels of Government - Federal, Provincial and Municipal. In general, legislation by Federal and Provincial Governments affects the vehicles whereas Municipal Bylaws affect mainly operating procedures.

3.1.1 Legislation Affecting Vehicles

Canadian motor vehicle legislation contains a clear jurisdictional delineation between vehicles at the point of manufacture/importation and vehicles in use. The former falls under Federal control, and the latter under the provinces(s) in which the vehicle is registered and/or operated.

(a) Federal Legislation

The Federal Motor Vehicle Safety Act, was brought into effect in 1971, and has subsequently been amended from time to time. The Act provides for the enforcement of safety standards for motor vehicles imported into and exported from Canada, or conveyed between provinces. Therefore, the vehicle, at the importer or manufacturer level, prior to sale is required to conform with the appropriate Canadian Motor Vehicle Safety Standards defined in the Consolidated Regulations of Canada, Chapter 1038. Part III of the Act (See Table 3.1) defines which of the present sixty-three individual CMVSS standards are applicable to the thirteen classes of vehicles defined in the Motor Vehicle Safety Regulations.

The classes of vehicles defined in the Motor Vehicle Safety Regulations which are relevant to Paratransit are as follows:

- passenger car
- multipurpose passenger vehicle (MPV)
- chassis - cab
- bus

The legal definition of each class of vehicle is given below along with typical standard commercial vehicles which fall under each classification:

PASSENGER CAR:

> ". . . means a vehicle having a designated seating capacity of ten or less, but does not include an all-terrain vehicle, competition car, multipurpose passenger vehicle, antique reproduction vehicle, motorcycle, truck or trailer."

This definition includes virtually all commercially available passenger cars with less than ten seating positions without four-wheel drive, and not built on a truck chassis. This class of vehicle is subjected to conformance with 41 CMVSS standards out of a total of 63, including stringent occupant protection standards.

TABLE 3.1

CANADA MOTOR VEHICLE SAFETY STANDARDS

		Classes of Vehicles												
EQUIPMENT	CMVSS	Bus	Chassis-cab	Competition Motorcycle	Competition Snowmobile	Minibike	Motorcycles, Motor Driven Cycles & Mopeds	Multipurpose Passenger Vehicle	Passenger Car	Snowmobile	Snowmobile Cutter	Trailer	Trailer Converter Dolly	Truck
Control Location	101	x	x					x	x					x
Shift Sequence	102	x	x					x	x					x
Defrosting Defogging	103	x	x					x	x					x
Wiping and Washing	104	x	x					x	x					x
Hydraulic Brakes	105	x							x					
Brake Hoses	106	x	x				x	x	x			x	x	x
Reflecting Surfaces	107	x	x					x	x					x
Lighting	108	x	x			x	x	x	x			x		x
Headlamps	108.1	x	x					x	x					x
Tires and Rims	110								x					
Rearview Mirrors	111	x					x	x						x
Rearview Mirrors	111.1								x					
Headlamp Concealment	112	x	x				x	x	x					x
Hood Latches	113	x	x					x	x					x
Locking System	114								x					
Vehicle Number	115			x			x		x					
Hydraulic Fluids	116	x	x				x	x	x			x	x	x
Power Windows	118							x	x					
Tire Selection and Rims	120	x	x				x	x				x	x	x
Air Brake Systems	121	x	x									x	x	x
Motorcycle, Motor Driven Cycle & Moped Brake Systems	122						x							
Motorcycle Control and Displays	123						x							
Accelerator Control Systems	124	x	x					x	x					x
Occupant Protection	201								x					
Head Restraints	202								x					
Impact Protection	203								x					
Steering Wheel	204								x					
Glazing Materials	205	x	x				x	x	x			x		x
Door Latches	206		x					x	x					x
Seat Anchorages	207	x	x					x	x					x
Seat Belts	208	x						x	x					x
Belt Assemblies	209	x	x					x	x			x		x

Table 3.1 continued

		Classes of Vehicles												
EQUIPMENT	CMVSS	Bus	Chassis-cab	Competition Motorcycle	Competition Snowmobile	Minibike	Motorcycles, Motor Driven Cycles & Mopeds	Multipurpose Passenger Vehicle	Passenger Car	Snowmobile	Snowmobile Cutter	Trailer	Trailer Converter Dolly	Truck
Belt Anchorages	210	x	x					x	x					x
Nuts, Discs, Hub Caps	211							x	x					
Windshield Mounting	212	x						x	x					x
Child Seating and Restraint Systems	213	x						x	x					x
Side Door Strength	214								x					
Bumpers	215								x					
Roof Intrusion Protection	216								x					
Bus Window Retention, Release and Emergency Exits	217	x												
Rollover Protection	220	x												
Joint Strength	221	x												
Passenger Protection	222	x												
Fuel System	301	x						x	x					x
Flammability	302	x	x					x	x					x
Axle	901											x		
Emission Device	1101	x	x					x	x					x
Crankcase Emission	1102	x	x					x	x					x
Hydrocarbon and CO	1103	x	x					x	x					x
Diesel Opacity	1104	x	x					x						x
Evaporative Emission	1105	x	x					x	x					x
Noise	1106	x				x	x	x	x					x
Lighting	1201									x	x			
Vehicle Number	1202				x					x				
Handgrips	1203				x					x				
Noise	1204									x				
Shielding	1205				x					x				
Engine Controls	1206				x					x				
	1207				x					x	x			
Tie Down	1208											x		
Tow Bar	1209										x			
Brakes	1210									x				
Fuel Tanks	1211									x				

MULTI-PURPOSE PASSENGER VEHICLES:

> ". . . means a vehicle having a designated seating capacity of ten or less that is constructed on a truck chassis or with special features for occasional off-road operation, but does not include an air-cushion vehicle, all-terrain vehicle, golf cart, passenger car or truck."

This definition includes virtually all vans with less than 10 seats, and four-wheel drive vehicles, and such vehicles must meet 32 of the possible 63 CMVSS standards. The relaxation in standards compared to standard cars is in the area of occupant protection, with no requirement in the area of Side Door Strength, CMVSS 214; Bumpers, CMVSS 215; Roof Intrusion, CMVSS 216; Occupant Protection, CMVSS 201; Head Restraints, CMVSS 202; Impact Protection, CMVSS 203; Steering Wheel, CMVSS 204; Hydraulic Brakes, CMVSS 105; Door Locking Systems, CMVSS 114; and Vehicle Identification Number (VIN), CMVSS 115.

CHASSIS-CAB:

> ". . . means a vehicle consisting of a chassis that is capable of being driven, drawn, or self-propelled, upon which may be mounted a cab, and that is designed to receive:
>
> (a) a passenger-carrying or cargo-carrying body including a body that incorporates a prime mover, or
>
> (b) a work performing structure other than a fifth wheel coupling."

This definition includes virtually all of the small bus or van-type vehicles which have a custom made rear passenger or cargo carrying body. As such, the vehicle must meet a total of 25 CMVSS standards, which represent a relaxation from the multipurpose passenger vehicle in the areas of: Nuts, Discs, Hub Caps, CMVSS 211; Windshield Mounting, CMVSS 212; Child Seating and Restraint Systems, CMVSS 213; Fuel System, CMVSS 301; Noise, CMVSS 1106; Rearview Mirrors, CMVSS 111; Power Windows, CMVSS 118; and Seat Belts, CMVSS 208.

BUS:

> ". . . means a vehicle having a designated seating capacity of more than 10, but does not include a trailer."

This definition includes all vehicles with 10 or more seats, including high capacity vans. As such, the vehicle must conform to 35 standards out of a total of 63. In comparison to a passenger car, the bus must meet a reduced number of standards (35 as opposed to 41), with special standards developed specifically for buses in the area of occupant protection.

Since the CMVSS standards tend to be very similar to their U.S. counterparts, the FMVSS standards, vehicles designed for acceptance in the U.S. market normally meet the Canadian requirements.

The standards are enforced via the process of self-certification wherein a manufacturer/importer must certify that his vehicles meet all of the appropriate CMVSS requirements, and provide, upon request, proof of compliance either through test results or engineering analysis. The Road and Motor Vehicle Traffic Safety Branch of Transport Canada is responsible for the enforcement of regulations under the Motor Vehicle Safety Act.

In 1977 an amendment was made to the Motor Vehicle Safety Act allowing exemptions to specific CMVSS standards for specific vehicles, subject to approval of individual applications. The grounds for granting an exemption are as follows:

(i) the creation of financial hardship for the manufacturer or importer applying for the application;

(ii) prevention of the development of new safety features that are equivalent to, or superior to, prescribed safety standards; or

(iii) prevention of the development of new kinds of motor vehicles and motor vehicle systems and components.

Exemptions are not granted if they would substantially degrade the safe performance of the vehicle, if the world production of vehicles by the manufacturer exceeds 10,000, or more than 1,000 of the vehicles are manufactured for or imported into Canada per year. If an exemption is granted, the following limitations apply:

(a) An exemption is granted for two years except in (i) above in which the exemption is granted for a period of three years.

(b) An exemption granted under (ii) or (iii) is limited to 1,000 units of the model exempted.

Thus the CMVSS standards, under the Motor Vehicle Safety Act, regulate the design of vehicles as related to safety considerations.

In 1975, in response to energy shortages, the Federal Government established the joint Government Industry Voluntary Motor Vehicle Fuel Economy Program. The Road and Motor Vehicle Traffic Safety Branch of Transport Canada has responsibility for this program. The original objectives of the program included:

1. publication and distribution of fuel consumption ratings;
2. labelling of fuel consumption information on individual cars and light duty trucks;

3. meeting corporate average fuel consumption values (CAFE), namely:

YEAR	L./100 km.
1980	11.8
1981	10.7
1982	9.8
1983	N/A
1984	N/A
1985	8.6

Legislation has been introduced in Parliament to make compliance with the above fuel economy standards mandatory, and it will likely become effective with the 1983 model year. As it regulates CAFE, it will not necessarily affect the design of individual vehicles, except that the manufacturers will be improving the fuel economy performance of all of their vehicles, in order to comply with the new standards.

(b) Provincial Regulations

All Canadian provinces possess Highway Traffic Acts or equivalent statutes, which regulate licensing of vehicles, traffic on provincial highways and the condition of vehicles in operation. The individual regulations are as follows:

a. Alberta: The Highway Traffic Act (1975)
b. British Columbia: Motor Vehicle Act (1979)
c. Manitoba: The Highway Traffic Act (1979)
d. New Brunswick: Motor Vehicle Act and Regulations (1955)
e. Newfoundland: The Highway Traffic Regulations (1970)
f. Nova Scotia: The Motor Vehicle Act & Regulations (1977)
g. Ontario: The Highway Traffic Act (1979)
h. Prince Edward Island: The Highway Traffic Act (1975)
i. Quebec: Highway Code (1976)
j. Saskatchewan: The Vehicle Act (1975)
k. Northwest Territories: Vehicle Ordinance (1967)
l. Yukon: Motor Vehicle Ordinance (1958).

In the province of Ontario, safety inspections in conformance with Schedules 1 and 2 of Regulation 326/79 are required for the resale or transfer of all vehicles, in accordance with sections 57(a) and (c) of the Highway Traffic Act. For buses and wheelchair vehicles safety inspections in conformance with Schedules 1 and 2 of Regulation 326/79 are required every six months. The safety inspections involve the following vehicle subsystems and must be carried out by a certified mechanic:

Schedule 1:

- body work
- brakes
- engine controls and steering
- suspension
- electrical
- lighting
- tires and wheels
- number plate

Schedule 2:

- wheel brake internal components

In addition, the Province of Ontario has issued a new regulation on "Vehicles for the Transportation of Physically Disabled Passengers", namely Regulation 167/81, under the Highway Traffic Act, effective September 1, 1981. The Regulation specifies the design or performance of the following vehicle subsystems:

- passenger access door
- emergency door
- interior finish and accessories
- exterior markings
- loading ramp
- power lift
- wheelchair securement devices
- occupant restraint assemblies
- wheelchair occupant restraint assemblies.

In addition, the Ontario Highway Traffic Act imposes the following:

PART V: Equipment

- defines required exterior lighting and use of seat belts.

PART VI: Load & Dimensions

- maximum allowable values

Para. 65 (1) - width: 2.6 metres (with some exceptions)
Para. 65 (5) - length, vehicle: 11.0 metres
Para. 65 (7) - length, bus: 12.5 metres
Para. 65 (9) - height: 4.15 metres

PART VII: Weight

Para. 72(1) - Maximum Axle Loadings
  - single axle, single tires = 9000 kilograms
  - single axle, dual tires = 10,000 kilograms

Due to the relatively small size of vehicles used in paratransit services, none of the limits set in Parts V, VI, and VII, impose severe design restrictions.

A review of other provincial standards indicated that the Ontario regulations tend to be the most comprehensive and/or stringent with the following exceptions:

- In British Columbia, safety inspections of motor vehicles are required every twelve months, including the following vehicle systems:
  - all lamps
  - body components
  - wheel alignment and steering
  - fuel and exhaust systems
  - brakes
  - seats

- In Nova Scotia, safety inspections of motor vehicles are required every twelve months, including the following vehicle systems:
  - windshield and glass
  - body components
  - horn, windshield wipers, mirrors
  - brakes
  - steering
  - suspension, tires and wheels
  - fuel system
  - lights

- In Quebec, taxis require bi-annual inspections, including the following vehicle subsystems:
  - headlamps
  - transmission
  - tires
  - brakes
  - general

Maximum vehicle dimensions vary from province to province, with the following limiting values.

(a) Maximum Widths:
- minimum value for passenger cars = 2.10 metres - Manitoba.
- minimum value other vehicles = 2.59 metres - Nova Scotia.
- maximum value = 2.60 metres - all other provinces.

(b) Maximum Height:
- minimum value = 4.11 metres - New Brunswick and Nova Scotia.
- maximum value = 4.42 metres - Prince Edward Island.

(c) Maximum Length: - (any vehicle)
- minimum value = 10.67 metres - New Brunswick
- maximum value = 12.5 metres - 4 other provinces

(d) Maximum Length: - (buses only)
- Minimum value = 12.5 metres - Ontario
- Maximum value = 12.19 metres for a 3 axle vehicle in New Brunswick.

(e) Allowable Axle Loads:
Axle load restrictions generally are set to restrict overloading of large trucks, and do not tend to limit the design vehicles of interest to this study. Allowable axle loads range from a low of 4100 kg for a single axle with single 900 x 20 tire, in Alberta, to a maximum of 12,700 kg for tire widths greater than 210 mm in New Brunswick.

3.1.2 Other Legislation

Taxi services in most Canadian cities are regulated by local governments, usually through municipal commissions. Only Quebec has an overall law governing the regulation of taxis in its cities, and in Manitoba the provincial government retains regulatory control over taxis in Winnipeg.

The Economic Council of Canada published a report in 1981 on government regulation of the economy. On the subject of taxi operations, the report notes that: although taxi regulations vary enormously across the country, nearly all have the same effect - they create monopoly situations by sharply limiting the number of cabs that may operate in any given area. Most also discourage the use of taxis by more than one passenger per trip (presumably the report intends to refer to one group of passengers as opposed to shared ride), maintain fees at rates that far surpass the actual cost of the service and affectively limit the number of jobs available in the industry and the income of drivers who rent vehicles from taxi owners. The result, according to the Economic Council of Canada report, is high cost and inefficient utilization of taxi services. The report calls for reform of taxi regulations to increase the number of taxis allowed to operate in any given area and for lower taxi fares, which would increase demand for taxi services. The net result would be a more efficient taxi industry and a closer integration of taxi transportation with other forms of urban transit.

Paratransit and taxi being, for purposes of municipal legislation, essentially interchangeable terms, the regulations applying to taxi operations are those that affect the provision of many paratransit operating modes. Despite its high cost, travel by taxi is becoming an indispensible means of transport for a large element of the population requiring transportation operating with flexible schedules and routes. Taxis are for many people - particularly the elderly, the handicapped and the disadvantaged - a necessary substitute for the private automobile and a much needed complement to urban mass transit systems.

A number of bylaws that control taxi (and thus paratransit) operation have been reviewed. As noted in the Economic Council of Canada report, these regulations vary enormously. Generally speaking, most do not seriously hinder the use of vehicles that are currently under development for paratransit purposes. In those cases where some aspect of a bylaw does pose a hinderance it is likely that in the majority of cases the bylaw could be amended. If the vehicle affected can pass the stringent evaluations of the Federal and Provincial governments, except for very particular cases, it would probably be acceptable for use in Canadian cities.

The area of operation that is currently most affected by municipal bylaws is the almost universal prohibition of shared ride operations. Increasing operating costs are causing a re-evaluation of this directive. Most municipalities also require a taxicab to be equipped with a taximeter, which is closely allied with the single fare requirement.

Two examples of particular municipal legislations that may have an impact on introduction of a new vehicle into taxi/paratransit service in specific centres are as follows:

- Ottawa
  - maximum number of persons to be carried in one trip by a licensed taxicab owner is five;
  - vehicle must have an encased automobile body having four doors and seating capacity for three or more persons, exclusive of the driver, and is designed with space for storage of luggage.
- Vancouver
  - the definition of a taxicab is a cab with a seating capacity of not more than seven passengers.

Certain Canadian cities have made differentiations in their municipal bylaws, between conventional taxicabs and vehicles used for the purpose of transporting physically handicapped persons. For example, the Regulations of the Taxicab Board and the Taxicab Act, Province of Manitoba (Cap. 260, R.S.M. 1954), Section 15 state "motor vehicles constructed so that each vehicle has in it a ramp upon which a wheelchair may be pushed up or down with a person seated in such chair and is being used for the transportation of physically handicapped persons, including their accompanying passengers, are exempt from the definition of taxicab and no fees or municipal taxes imposed under this act shall apply to such vehicles". Similarly, in Vancouver, a Class 'L' Handicapped Transportation Cab - a cab that is used exclusively for transporting passengers confined to wheelchairs - has to pay a $50 license fee as opposed to an $80 fee for a taxicab. The Vancouver regulation is more restrictive and less generous than that of the Province of Manitoba but is, nevertheless, a step in the right direction respecting provision of services to handicapped persons.

3.2 Review of Other 'Sample' or 'Model' Legislations

Two sets of legislation have been reviewed in addition to the review of the existing legislation of major Canadian cities.

An example of stringent regulations respecting taxis are the laws applicable in London, England. It is evident from these that the introduction of any vehicle, other than those currently utilized, would be most difficult.

In London the Assistant Commissioner of Police has responsibility for regulating the physical characteristics of vehicles and the qualifications of drivers.

Every cab must comply with Part II, Conditions of Fitness, in construction and licensing of motor cabs in London. Some of the more specific points respecting vehicle design are as follows:

Turning Circle

- Vehicle must be capable of turning on either lock so as to proceed in the opposite direction without reversing between two vertical parallel planes not more than 8.535 metres apart.
- The wheel turning circle curb to curb on either lock must not be less than 7.62 metres in diameter.

Dimensions

- Overall width of the vehicle exclusive of driving mirrors must not exceed 1.755 metres.
- Overall length must not exceed 4.575 metres.
- The vertical distance between the point of maximum deflection of the seat cushion when a passenger is seated to the roof immediately above that point must not be less than 96.5 centimetres.
- The width across the rear seat cushion must not be less than 1.07 metres.
- Any curvature of the floor of the passengers' compartment must be continuous and must not exceed 2 centimetres at the partition and 5 centimetres at the base of the rear seat when measured between the centreline and the sills.
- The door and doorway must be so constructed as to permit of an unrestricted opening across the doorway of at least 53 centimetres when the door is opened to its normal limit.
- The clear height of the doorway must not be less than 1.195 metres.
- The top of the tread of the lowest step for any entrance, or where there is no step the floor level itself at the entrance, must not be more than 38 centimetres above the ground when the vehicle is unladen.
- The measurements from the upholstery at the back to the front edge of the seat must not be less than 40 centimetres in the case of the back seat and 35.5 centimetres in the case of the front seat.
- The width of each front seat must not be less than 40 centimetres.
- The vertical distance between the highest point of the undeflected seat cushion and the top of the floor covering must not be less than 35.5 centimetres.

- Where seats are placed facing each other there must be a clear space of 48 centimetres between any part of the front of a seat and any part of any other seat which faces it. This measurement may be reduced to 43.5 centimetres provided adequate foot room is maintained at floor level. Where all seats are placed facing to the front of the vehicle, there must be a clear space of at least 66 centimetres in front of every part of each seat cushion.
- Front seats must be so arranged as to rise automatically when not in use. They must be symmetrically placed and at least 4 centimetres apart. When not in use front seats must not obstruct doorways.
- Every cab must be provided with an approved means of communication between the passenger and the driver. When a sliding window is fitted at the rear of the driver's compartment, the maximum width of the opening must not exceed 11.5 centimetres.

In the mid 1970s the United States Department of Transportation funded a study regarding the regulation of various types of public paratransit transportation, the result of which was a publication comprising a complete set of provisions for such regulation (A Compendium of Provisions for a Model Ordinance for the Regulation of Public Paratransit, prepared by the International Taxicab Association, February 1976). This project included the collection and review of the statutes of every State and the ordinances of some six hundred municipalities. The review revealed that few of the regulations were complete and that some communities had very little real regulation. The compilation of the model compendium does not include description of the vehicles which offer the services, but rather the description and regulation pertains to the service itself. Conventional regulations in this area concern themselves first with the vehicle and secondly with the service.

The scope of this study is to include regulatory requirements "on the vehicle technology and other operating characteristics of taxi and paratransit services that impinge on the vehicle design to be applied in Canada". The compendium of provisions makes little reference to such matters other than the following:

- every vehicle rendering taxicab service shall be equipped with a taximeter and a light on the exterior of the roof to be illuminated when the operating lights are lit and the taximeter is in operation.

Also listed are a number of features, such as power operated windshield wipers and windshield defrosters that are considered to be included in any case.

3.3 Implications of Legislation on Vehicle Technology and Design

Generally speaking, municipal regulations are the area that determine whether or not a newly developed vehicle will be admitted into service. The Federal and Provincial regulations that govern the design and safety parameters of the vehicle must already have been complied with prior to attempting to introduce the vehicle to the marketplace. These latter regulations can be considered inflexible in that they have been progressively developed over years and radical changes, or exceptions permitted to the regulations, are highly unlikely. The regard with which these regulations are viewed is demonstrated in the fact that insurance companies will insure vehicles that meet these requirements, without imposing additional insurability regulations.

Municipal regulations can prohibit a newly developed vehicle that has met all Federal and Provincial regulations from being used in a taxi or paratransit role. These regulations are not inflexible. Bylaws can be changed and, in many cases, the reason for their current wording is because they have never been questioned, despite possible radical changes in both operating modes and vehicle technology since the bylaw was written. In cases where bylaws may not permit the use of a certain type of vehicle it may be possible to provide a special permit for use of that vehicle. This has in fact recently been done in a major Canadian city to permit the use of the GSM taxi.

The current Federal and Provincial regulations regarding vehicle specifications are well justified and require no change. Vehicle producers must abide by these regulations. Some municipal regulations do impose hardship in introduction of a new vehicle, however these regulations can often be changed and if a new vehicle does offer benefits these changes will be made. Few current municipal bylaws impose any real restrictions on introduction of new vehicles.

4.0 VEHICLE SPECIFICATIONS

Vehicle specifications must comply with the existing legislation. Insurance requirements are potentially of assistance in initially determining appropriate vehicle specifications, in that any reduction in insurance premiums is beneficial to the paratransit operator.

Operational requirements will determine the majority of vehicle specifications. These requirements must be addressed in detail in order that the proposed vehicle is both efficient and effective in its anticipated role. In addition to the operational requirements there may be further requirements identified by special interest groups, that should also be considered.

4.1 Insurance Requirements

One of the largest taxi insurance underwriters in Canada is the Royal Insurance Company, which supplied the data utilized in this section.

In order for a motor vehicle to be insurable, it must be licensed for operation in a given province. Therefore, as long as the design and/or condition of the vehicle can meet the provincial licensing standards, a vehicle can be insured. Most commercial taxi or paratransit firms carry two types of insurance coverage on their vehicle fleets; public liability/property damage and collision. Public liability/property damage covers damage to other vehicles, and bodily injury and property damage. Collision insurance covers the insured vehicle for collision or upset.

Due to their relatively high exposure, taxi fleets insurance coverage costs approximately 10 times as much as a typical private vehicle (i.e., taxi insurance costs $2500 to $3000 per year for $300,000 public liability/property damage, collision with $1000 deductible, and vandalism/theft, with $50 and $1000 deductible respectively).

These insurance rates are based upon a loss history for the taxi industry or a particular fleet. If a new vehicle is introduced with design features which will reduce either the frequency or severity of accident claims, then insurance rates can be decreased, but only after an extended period of reduced claims. The length of this trial period would likely range from 2 to 5 years, and the reduction in insurance rates would be based upon the degree of savings over the five year period.

It is estimated by Royal Insurance that up to 95% of the insurance claims are driver caused, and 85% involve only physical losses and 15% human injury. The relatively high loss rate of taxis is due to their high exposure rate (in terms of distance travelled per year) and high frequency of accidents (per 1000 kilometres travelled), due to the nature of the business which involves moving from point A to point B in the urban core as quickly as possible, frequently bending or breaking the traffic rules.

Table 4.1 indicates the areas of vehicle design that could have a beneficial effect on insurance rates following a proven history of loss prevention or reduction.

Insurance rates can be reduced for an improved vehicle, but only after an extended period of usage clearly proves that reduced claims do result from the use of the improved vehicle. Conversely, no insurance restrictions exist which would preclude a licensable vehicle from being insured for a paratransit or taxi operation.

TABLE 4.1

VEHICLE DESIGN AREAS FOR INSURANCE BENEFITS

DESIGN FACTOR	EFFECT	INSURANCE COVERAGE AFFECTED
Reduce frontal agressiveness of vehicle body	Reduce pedestrian injury	Public liability, property damage
Improve occupant protection	Reduce driver/ passenger injury	Public liability
Improve driver controls/view	Reduce driver fatigue and reduce accident frequency	Public liability and collision
Improve body/ structural repairability	Reduce cost of collision repair	Public liability and collision
Improve ease of entrance/egress	Reduce frequency and severity of passenger claims	Public liability

4.2 Operational Requirements

In developing paratransit vehicle specifications it is imperative to first define the service to be rendered, and let the service define, as far as possible, characteristics of the required vehicle. Paratransit services are provided to a nonhomogeneous ridership, including a significant number of elderly and handicapped citizens. These services incorporate a variety of modes including: rental vehicle, taxi (both shared ride and exclusive ride), dial-a-ride, jitney, car pool and subscription bus.

Paratransit operational requirements vary somewhat with the nature of the fleet and the mode, but can generally be characterized as follows:

- To provide passenger transportation for the general public through demand-responsive scheduling and/or flexible routing of vehicles.

- The optimum capacity of a paratransit vehicle depends upon trip length and passenger volume, but the service is normally utilized only at passenger volumes lower than those required to warrant a regular fixed schedule transit bus. Estimates of the optimum vehicle capacity range from a low of 4 to 6 regular passengers for a taxi operation to 15 to 20 passengers for a subscription bus service. (These larger vehicles are beyond the scope of this study).

- The vehicles must be capable of transporting the elderly and handicapped (including wheelchairs) easily even though this requirement may occur relatively infrequently. It is highly desirable that a portion (if not all) of each paratransit fleet is comprised of vehicles capable of accommodating passengers in wheelchairs. A high proportion of persons in wheelchairs experience difficulty transferring from the wheelchair, as is required with a conventional vehicle where the wheelchair is stored in the trunk. Furthermore, the increasing utilization of electric wheelchairs, which cannot be folded for stowage, increases the need for vehicles capable of carrying passengers in their wheelchairs.

- Ease of entrance and egress for both the general public and the elderly and handicapped must be excellent, in order to minimize loading/unloading delays which inconvenience the other passengers, and affect the overall level of service.

- The vehicle must conform, in its performance and exhaust emissions, to requirements of the Motor Vehicle Safety Act, to which fuel economy is likely to be added in the near future.

- The vehicle interior must be comfortable for the passengers and give some perception of privacy and security, as paratransit competes directly with the private automobile in many of its modes. Sufficient luggage capacity must be provided for the passengers' belongings.

- The vehicle must be durable, have low life cycle costs and good maintainability, reliability and availability.

- The vehicle must achieve good fuel economy, and should be capable, with minor modification, of operating on the various alternate fuels in use or proposed (in the short term).

- The vehicle must possess good acceleration, braking and maneuverability, to operate efficiently in congested urban areas.

In summary, the vehicle is required to be accessible to all passengers; have sufficient space for their proper movement and the storage of their luggage, wheelchairs, and cargo; be safely constructed, and have proper seating facilities for the passengers and driver (keeping in mind the possible physical handicaps of the passengers). It should also carry equipment necessary for the easy access and egress of the handicapped, plus fare calculation and fleet dispatch communication equipment, where appropriate.

4.3 Shortcomings of Existing/Proposed Vehicles

The vehicles presently in use in paratransit services (passenger cars, special taxi vehicle, standard van, modified van and small bus) are discussed individually below with regard to their shortcomings:

(a) Passenger Car:

Recent downsizing trends have reduced the capacity of the standard sized vehicle to the point where it has limited application in paratransit roles.

The ease of entrance and egress of the passenger car have been reduced by downsizing to the point where these vehicles are unacceptable for transporting the elderly and handicapped.
The passenger car is incapable of transporting a disabled person in a wheelchair, and many models can no longer carry a folded wheelchair in their trunk.

The durability of the vehicle is relatively poor in commercial roles, as it was never designed for a commercial duty cycle. High maintenance costs and low availability normally result after the first year or two of operation.

(b) Special Taxi Vehicle:

The only commercial available special taxi vehicle is the Checker, which has the following shortcomings;

- Relatively high capital cost
- Poor fuel economy, due to high weight, and large gasoline fueled engine
- Relatively rough ride in comparison to passenger cars
- Dated body design has little aesthetic appeal to riders

- The vehicle cannot transport a disabled passenger in a wheelchair, due to limited headroom

- On the positive side the vehicle has proven durability, and a spacious passenger compartment.

The GSM taxi, presently in development, has overcome many of the disadvantages of the passenger car and the Checker taxi for paratransit applications. The following points indicate the design advantages of the GSM vehicle.

- Spacious interior for five to six passengers

- Adequate room for a wheelchair passenger plus two seated passengers
- Ease of entrance/egress is good for both ambulatory and wheelchair passengers (via a manually deployed ramp)

- The vehicle interior is spacious, comfortable and gives a feeling of privacy and security

- The vehicle is designed to be durable in its intended role, using suspension and drive line components from an existing light duty truck.

The vehicle suffers from a relatively high capital cost and unproven durability in its intended role. It does represent a major design step forward and it could have an appreciable effect on paratransit services in Canada and the United States, if it reaches production.

(c) Standard MPV:

This vehicle, namely the van, currently provides paratransit services in a wide range of roles. The van is undergoing downsizing in a manner similar to the passenger car, and present and near term versions of the vehicle have the following disadvantages for paratransit services:

- Difficult entrance and egress, particularly for the elderly and handicapped, caused by its high floor level and limited headroom

- A relatively rough ride in comparison to a passenger car

- Relatively low durability in commercial operation

- Relatively poor fuel economy in urban operations

- Limited interior privacy in comparison to a passenger car

The main advantages of the van are low capital cost and high seating capacity.

(d) Modified MPV:

Modified vans are widely used in paratransit roles, and depending upon the degree of modification, all but the following disadvantages can be eliminated:

- Rough ride in comparison to a passenger car
- Difficult entrance/egress, for elderly and handicapped, due to high floor height
- Low durability in commercial operation
- Poor fuel economy in urban operations

Nevertheless, these vehicles find wide application, as they achieve good seating capacity, with adequate headroom, for minimum capital cost.

(e) Small Bus:

These vehicles are widely used for several paratransit modes, in spite of several disadvantages:

- Relatively high capital cost
- Limited durability, particularly for body on chassis configurations
- Limited interior privacy
- Difficult entrance/egress for the handicapped
- Rough ride in comparison to a passenger car
- Relatively poor fuel economy

In a recent United States project, originally funded by UMTA, various firms developed the vehicles described in Section 2.3 in response to the vehicle requirements indicated in Table 4.2. Subsequently, Winnebago Industries developed, using internal funds, the family of paratransit vehicles described in Section 2.3 of this report. Each of these vehicles interpreted the requirements of Table 4.2 in a slightly different fashion, and while they were

TABLE 4.2
VEHICLE REQUIREMENTS FOR UMTA FUNDED PROJECT

Capacity:	Type A - 4 to 6 Regular Passengers + 45.5 kg. Type B - 1 wheelchair + 2 to 4 regular passengers. Type C - 455 kg cargo, no passengers.	
Convertability:	Maximum 2 hours between types A, B and C.	
Floor:	Flat, 30.5 to 35.6 cm above street level.	
Dimensions:	Interior Headroom	147.3 cm
	Height of Door	142.2 cm
	Width of Door	81.2 cm
	Overall Height	190.5 cm
Acceleration:	0 to 67 kph in 10 seconds.	
Fuel Economy:	11.4 km/litre in EPA urban cycle.	
Maintainability:	Minimum downtime for inspection and replacement of power train. Disc brakes on all four wheels	
Access:	Easy and fast entry for all passengers. Suitable for shared ride service. Wheelchair access by ramp.	
Cost Goal:	125% of conventional taxicab.	
Standards:	Meets all applicable Federal Motor Vehicle Standards.	

largely in compliance with the elements of the specification, each vehicle is markedly different from the others.

As these were purpose-designed vehicles they each represent an improved vehicle for paratransit service. The principal disadvantages of the vehicles are their relatively high capital costs, and the fact that they are of unproven durability and are not yet commercially available. The McFarland Vehicle has the disadvantage of an all-aluminum body, which poses repairability problems, plus a suspension system/front wheel drivetrain which is loaded beyond its design limits. The Minicars vehicle is faced with this latter problem plus the fact that it has limited internal room/passenger capacity. One particular Winnebago vehicle, a modification of a Renault van, is relatively unsophisticated in comparison with the others, but may have the best chance of commercial viability due to the simplicity of the modifications, and the production and after market service capability of Winnebago.

In summary, all of the existing commercially available vehicles used in paratransit service possess operational shortcomings as they were not developed specifically for paratransit service. Conversely, those vehicles developed specifically for a paratransit role are not presently commercially available.

4.4 Vehicle Technology

The configuration of a paratransit vehicle involves the following vehicle systems:

- frame/chassis
- suspension/steering/brakes
- power plant
- drive train
- body
- vehicle interior

Each of these systems will be discussed briefly with respect to the present state-of-the-art, and regulatory, developer, supplier, operator and user considerations.

(a) Frame/Chassis

Present vehicle design tends to include either full-ladder type frame, full X-frame, unibody or monocoque body. The monocoque or unibody approach was developed to produce high stiffness with low weight by using the vehicle body framework and panelling as a frame. These design objectives were met but problems were caused by body corrosion leading to structural failure, and also with collision damage repairability. It is generally accepted that in order to maximize durability and achieve good collision damage repairability, a full frame/chassis is highly desirable, particularly in commercial vehicles. The introduction of graphite-reinforced composite materials in vehicle frames may become viable if their costs can be reduced relative to present frame materials. The composites have excellent strength-to-weight ratios and corrosion resistance. The repair technology for these high strength materials is not yet in place commercially, but it will occur if the materials become widely used. For the near term a full steel frame appears to be the appropriate design for paratransit vehicles.

(b) Suspension/Steering/Brakes

Suspension systems for vehicles are classified as independent and non-independent (solid), depending upon the mechanical interrelationship of wheels on the same axle. Non-independent suspension systems are characterized by rigid transverse structural members connecting two or more of the wheels so that a vertical displacement of one of the wheels causes the movement of the interconnected wheel. Independent suspensions have reduced unsprung mass, which leads to improved handling and traction characteristics at high speed. In addition, ground clearance, wheel shimmy and axle tramp are improved and lower rate springs can be used, providing a smoother ride.

As an integral part of the suspension system various spring and damping devices are utilized to provide good ride and handling characteristics. Spring devices/materials utilized include: helical compression springs, leaf springs, torsion bars, pneumatic springs, hydraulic springs, hydropneumatic springs, torsion-elastic springs, volute and helical torsion springs. In addition, damping devices (shock absorbers) which have been utilized, include hydraulic, friction, pneumatic, dynamic and inertial.

Current North American medium and heavy duty vehicles (vans and light trucks through to buses) presently utilize, almost exclusively, the following suspension arrangement:

- non-independent dead front axle fitted with coil springs and shock absorbers.
- non-independent live rear axle fitted with leaf springs and shock absorbers, (occasional coil springs on rear axles).

Full size passenger cars utilize a similar suspension system, but typically use coil springs on the live rear axle.

Compact and intermediate passenger cars are presently largely front wheel drive using an independent front suspension with coil springs and shock absorbers. These are frequently configured in a concentric fashion with a single suspension control plate, named the McPherson Strut. This configuration has the advantage of low unsprung weight, good ride features, and a compact volume. The rear axle on these vehicles is normally a dead beam axle on coil springs and is fitted with shock absorbers.

The appropriate suspension selection for a paratransit vehicle depends upon whether it is front or rear wheel drive, but where feasible, independent suspension is preferable as it gives improved ride and handling characteristics.

Vehicle service brake systems currently utilize either drum brakes or disc brakes fitted to each wheel. The former system utilizes a stationary internal expanding brake-shoe which contacts the inner circumferential surface of the rotating circular brake drum. The latter system uses a stationary brake caliper assembly which forces a set of pads against the side faces of the rotating brake disc. In both systems, the brake actuating force is transmitted hydraulically from a master cylinder operated by the vehicle brake pedal. The individual wheel brake cylinders act mechanically on the brake pads in the case of disc brakes, and brake shoes in the case of drum brakes. With proper design, either system is capable of providing good performance and durability. Nevertheless, the disc brake has a definite edge in terms of better cooling, reducing brake fade, and ease of replacement, thereby reducing maintenance costs.

Previously, North American vehicles used drum brakes almost exclusively, and disc brakes, particularly on all four wheels, were reserved for expensive sports cars. Recently, the industry has changed over to front disc brakes on virtually all vehicles, and four wheel disc brakes are appearing on more high performance vehicles.

In an effort to reduce brake pedal effort on larger vehicles, power brake or brake booster systems have been developed. The boost for these systems is frequently developed from manifold vacuum (gasoline engines) or compressed air, or from other fluid pressure sources such as the power steering pump. In the event of failure of the boost source, the system operates on a mechanical, unassisted basis. In order to minimize driver fatigue, and maintenance costs, while achieving good performance in stop-and-go urban traffic, a power assisted disc brake system is recommended for paratransit use.

The vehicle steering system enables the direction of the vehicle to be changed and corrected at will. The steering system consists of the steering wheel/shaft/box, the Pitman Arm, tie rod, drag links and steering arms connected to the wheels. In the steering box, the rotary movement of the steering wheel is converted into rotation of the sector shaft (Pitman Arm) or axial movement of a rack, with suitable gearing. Four types of steering boxes are utilized; rack and pinion steering, worm and sector steering, cam and peg steering and recirculating-ball steering. The steering linkage design is determined by axle construction and steering geometry and must meet the basic requirement that vertical movements of the road wheel should not exert any rotary forces on the steering assembly.

Power steering is widely used on North American vehicles, as it greatly reduces steering wheel effort by utilizing power from an external source; usually an engine-driven hydraulic pump.

The steering geometry for a paratransit vehicle should be designed to provide maximum manoeuvreability (small turning radius) while achieving good handling with low driver fatigue through the use of a power assisted steering system.

(c) Power Plant

The power plant requirements relevant to paratransit vehicles are as follows:

- durability in excess of 300,000 kilometres without a major overhaul;
- fuel economy - minimum feasible. The resultant paratransit vehicle must comply with the fuel economy standards as required by Transport Canada;
- fuel sensitivity - capable of running on somewhat degraded commercial fuels which are proposed for the near term;
- fuel convertability - can be retrofitted with modifications to operate on alternate fuels presently proposed for use;
- reliability - should be equivalent to that of a diesel engine;
- maintainability - should be capable of being repaired by a licensed mechanic;
- capital cost - should be such that the life cycle cost of the engine is lower than that of other contenders;
- emissions - must meet the requirements of the Motor Vehicle Safety Act.

The types of power plants which are candidates for this vehicle role would include the following:

- spark ignition engines (OTTO Cycle)
- compression ignition engines (Diesel Cycle)
- external combustion vapour engines (Rankine Cycle) ie. steam engines
- external combustion (Stirling Cycle)
- gas turbines (Brayton Cycle)
- electric motors, battery storage
- electric motors, fuel cell storage
- hybrid propulsion systems (electrical/internal combustion)

The only candidate power plants which currently meet the paratransit requirements, are in commercial production and have proven durability are the gasoline and diesel internal combustion engines. Both of these engines are available in a wide variety of configurations and capacites suitable for vehicular use, and are undergoing continuous development to improve their power-to-weight ratio, fuel economy, emission levels, and durability.

The North American light duty motor vehicle engine is undergoing a strong downsizing trend. Previously most vehicles were powered by large displacement V-8 or 6 cylinder inline configurations. Presently, reduced displacement 4 cylinder and V-6 engines power the bulk of North American passenger cars.

Recent developments include the use of turbocharging to improve peak output and average fuel economy, plus engine weight reduction via material substitution and design refinements. Fuel economy and emissions improvements have also resulted from the introduction of electronically controlled fuel injection, and ignition systems, plus the introduction of throttle-body fuel injection systems in lieu of conventional carburetors. These engines with relatively minor modifications, can be made to operate on alternate gaseous and liquid fuels, including propane, compressed or liquified natural gas and methanol/ethanol or methanol/gasoline blends.

If a spark-ignition engine is utilized in paratranist service it should be of 4 cylinder or V-6 configuration, and turbocharged to provide good acceleration performance while achieving good fuel economy and emissions.

In a similar vein, high speed diesel engines are becoming increasingly popular in both North American and European passenger cars. The principal objections to older diesel engines, namely sluggish performance, poor starting, and excessive smoke/odour have been largely overcome by modified glow plugs and turbocharging systems. These automotive diesel engines are now available in a wide range of configurations/capacities, including 4, 5, and 6 cylinder in-line, and V-6 and V-8, both air and liquid cooled. With their outstanding fuel economy and durability these engines are good candidates for paratransit vehicles provided that their capital cost results in a lower life cycle cost than other candidate power plants.

(d) Drivetrain

The principal elements of the drivetrain include the transmission, driveshaft(s), and differential. Candidate transmissions include hydrostatic automatic, hydrokinetic automatic, continuously variable mechanical, and manual.

Only two of these transmissions are commercially used; a manual transmission with clutch assembly, or an automatic transmission with torque converter.

Manual transmissions which are available in 3, 4, and 5 speeds, have been characterized as having lower capital cost and lower parasitic losses, resulting in improved fuel economy, as opposed to automatic transmissions. However, the fuel economy actually achieved and the durability of the transmission are largely dependent upon the skill and diligence of the vehicle driver. Driver fatigue is increased when manual transmissions are utilized in congested urban traffic, and the requirement to frequently remove one hand from the steering wheel during shifting can affect the drivers ability in an abrupt accident avoidance manoeuvre.

The parasitic losses in the automatic transmission have been greatly reduced with the introduction of torque converter lock-up which occurs either in the top gears only, or above a specified speed in all gears. In addition, these transmissions which were previously only available in two or three speed versions are now available with a fourth (or overdrive) speed which improves fuel economy.

Although the weight and cost of an automatic transmission are somewhat higher than a manual transmission, the reduction in driver fatigue generally more than offsets these factors, and the automatic transmission with torque converter lock-up is recommended for paratransit use. For heavy commercial service it may be adviseable to fit an auxiliary transmission oil cooler to enhance transmission durability.

The type of differential assembly utilized depends very much on whether the vehicle is front or rear wheel drive and if the suspension system is independent or non-independent. For front wheel drive the differential assembly is normally close-coupled to the transmission. For rear drive independent suspension vehicles, the differential is a self-contained module attached to the vehicle frame, and linked to the road wheels via a pair of half-shafts. For rear drive non-independent (live) axles the differential is part of the axle assembly, housed inside a module which also contains the axle shafts and wheel bearings. In rear drive vehicles, a drive shaft fitted with universal joints is utilized to transmit the torque from the transmission output to the differential input.

On front wheel drive vehicles large drive-line angles occur during steering, and constant velocity or homokinetic joints are required to transmit torque evenly. The steering angle of front wheel drive vehicles is limited by drive shaft angularity problems, to values lower than rear wheel drive vehicle steering systems. For a given wheelbase, a front wheel drive vehicle will normally have a larger turning radius and be somewhat less manoeuvreable.

For the paratransit vehicle, the requirement for low floor height and a large flat floor area is best met by a front wheel drive vehicle with the maximum achieveable steering angle on a given wheelbase to achieve good manoeuvreability. In addition, an automatic transmission with torque converter lock-up should be fitted along with power-assisted disc brakes on all four wheels, plus power-assisted steering.

(e) Body

The body of a vehicle provides an enclosure for all of the vehicle systems and the driver/passenger/cargo. In the case of a partial or full monocoque body, it also serves as the frame of the vehicle, supporting all of the vehicle systems. The main components of a vehicle body include: structural members, panels, doors, windows, hood, trunk, and floor panels/structure. To date only three materials have been widely used for body structure and/or panels: steel (mild or high strength, low alloy), glass-reinforced fibre plastics (ie. reaction injection moulding of urethanes), and aluminum.

The present trend towards downsizing and decreasing vehicle weight has caused a significant change in the materials used to fabricate vehicle bodies. By 1985 it is estimated that high strength steels, aluminum alloys and plastics, will account for approximately 30% of the average car and light duty truck, compared to 15% for similar 1978 vehicles.(1) For paratransit vehicles, the following body characteristics are important:

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(1) Reference 12

- low weight for good fuel economy;
- good damage resistance to minor accidents, scratches, etc.
- good repairability (panel repair, in place, for minor damage, and easy panel removal/replacement for more severe damage).
- good corrosion resistance.

The use of aluminum structure and panels in the body of a paratransit vehicle would lead to damage resistance, and difficulties in repair of body damage, due to the high skill level required to repair aluminum sheets.

It is recommended that for paratransit vehicles a steel body be attached to the chassis and that glass-reinforced individual panels be attached to the frame by removeable fasteners, to form the main body structure. A damage resistant perimeter bumper system of moulded urethane, such as that utilized on the GSM prototype, would provide a good means of protection from minor scrapes and scuffs. With regard to doors, the vehicle configuration should incorporate relatively wide passenger doors, both curbside and roadside, in addition to an access door for the driver. Consideration must be given to an emergency exit capability in the event that the vehicle tips onto its side. The drivers window would open either as a sliding or roll-down, for paying tolls, and ventilation.

The question of vehicle exterior size has undergone considerable debate, but in a recent report the following recommendations were made (1):

- overall length	- 5.1 metres
- overall width	- 1.93 metres
- overall height	- 1.91 metres
- min. door width	- 0.86 metres
- desirable door width	- 0.91 metres
- min. door height, for normal passengers	- 1.45 metres
- desirable door height for handicapped	- 1.83 metres

The above dimensions seem generally appropriate for use in the Canadian context, depending upon the paratransit mode for which the vehicle is intended.

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(1) Reference 11

In order to permit the loading of wheelchair passengers, the curb-side passenger door should be fitted with a ramp system, either automatically or manually deployed, should have a slope no greater than 12:1 when the vehicle is adjacent to a 12.7 cm curb. This, in turn, leads to a low vehicle floor height of no more than 0.3 m, in order to achieve a practical ramp length of 2 m or less. The width of the ramp should be at least 0.81 m with raised sides to keep the wheelchair wheels on the ramp. The ramp should be covered with anti-skid material, and be lightweight and collapsible for easy storage in the vehicle.

(f) Vehicle Interior

The vehicle interior is composed of three specific areas, the passenger area, the driver area, and the luggage area. Vehicle systems involved in these areas include seating, windows, floor area/configuration, heating/ventilating/air conditioning systems, interior lighting, and communication and fare calculation. A previous study has indicated that the passenger area should meet the following minimum requirements (1):

- interior headroom 1.47 m
- floor area - flat, with dimensions of at least 1.22 x 0.63 m
- floor height, above street 0.3 m

In addition, the same study concluded that four different vehicle types were required to cover the spectrum of paratransit modes;

1. A four passenger vehicle (3 in rear and 1 in front with the driver) for exclusive and shared ride taxi service.

2. A six passenger vehicle (3 in rear, 2 on jumpseats and 1 in front with the driver) for taxi and limousine service, jitney and some dial-a-ride services. This vehicle would have wide doors, and a flat floor to accommodate the ambulatory handicapped.

3. A twelve passenger vehicle for jitney and dial-a-ride service. The vehicle would have wide doors, flat floors and would accommodate non-wheelchair handicapped.

4. A high roof vehicle for service to handicapped persons including wheelchair passengers.

The authors of this study feel that the fourth point above should be combined within each one of the first three vehicles, and that the resulting three vehicles would adequately cover the spectrum of paratransit modes.

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(1) Reference 11

The interior of the passenger compartment should have a flat floor, and should be fitted with fixed seats, folding seats, and a wheelchair restraint(s), as required by the vehicles design capacity. Occupant restraint systems should be fitted in accordance with CMVSS 208, 209 and 210 and any relevant provincial or municipal regulations. Side and rear windows should be provided at eye level to permit an easy field of view to the exterior.

The drivers compartment must contain accommodations/restraints for the driver plus all instruments/controls necessary to operate the vehicle. The drivers space is his place of work for long hours and should be as functional and comfortable as possible to minimize fatigue. The drivers seating position should include the following considerations:

- positioned so as to perceive and respond to all components of the driving task;
- proper ergonomic relationship with all controls and instruments;
- minimization of fatigue;
- ease of entry and egress;
- ease of observation and communication with passengers;
- proper access to dispatch/communication equipment and fare computation equipment.

In addition to the driving task, the driver is required to carry out the following:

- fare collection and securement (where appropriate to the mode), including associated safety problems;
- effective and efficient navigating from origin to destination under constantly changing traffic conditions;
- aid to passenger entry and exit, with particular emphasis on elderly and handicapped, plus luggage.

Luggage can be carried either in the trunk, on a roof rack, or in some cases, such as the GSM vehicle or the London taxi cab, a compartment adjacent to the drivers position. Consideration should be given to the fitting of a transparent (LEXAN) security screen between the driver and passenger compartments in order to provide security for the driver. The shield should allow communication between the driver and passengers, plus passage of currency to pay for the fare, where required.

Heating and defrosting equipment should be fitted to both the passenger and drivers compartments to provide adequate comfort and good visibility during periods of low ambient temperature. In warm climates, air conditioning should be fitted to reduce driver fatigue and provide passengers with a comfortable environment. Sufficient handles should be fitted to the interior of the vehicle to facilitate the entrance and egress of the elderly and handicapped.

Interior lighting in the passenger compartment should automatically illuminate, for safety reasons, the doorway and/or wheelchair ramp during loading/unloading operations.

The vehicle technology considerations discussed in this section were used to develop the paratransit vehicle specifications presented in the following section.

4.5 Paratransit Vehicle Specifications

A review of the specifications for currently available vehicles indicates that they all have some shortcomings for extensive use in the paratransit mode. Consequently a set of "model" specifications has been developed for paratransit vehicles. The specifications apply to vehicles of the following three capacities, including both desirable and acceptable levels of design/performance:

Vehicle A - 4 to 6 seated passengers or 1 wheelchair plus 2 passengers

Vehicle B - 6 to 8 seated passengers or 2 wheelchairs plus 2 passengers

Vehicle C - 9 to 12 seated passengers or 2 wheelchairs plus 6 passengers.

Table 4.3 presents the detailed specification of the three vehicles to the desirable and acceptable levels of performance/design.

TABLE 4.3

PARATRANSIT VEHICLE SPECIFICATIONS

Item	Desirable Level	Acceptable Level
General		
Body Type	4 door sedan(1)	
Curb weight (kg)	A = 1410, B = 1690, C = 2030	A = 1590, B = 1860, C = 2230
Weight distribution, F/R	50/50	60/40
Capacity		
Version A	4 to 6 seated, or 1 wheelchair, plus 2 passengers	4 seated or 1 wheelchair, plus 1 passenger
Version B	6 to 8 seated, or 2 wheelchairs, plus 2 passengers	5 seated or 2 wheelchairs, plus 1 passenger
Version C	9 to 12 seated, or 2 wheelchairs, plus 6 passengers	8 seated, or 2 wheelchairs, plus 4 passengers
Vehicle Size		
Wheel base (m)	A = 2.60, B = 3.70, C = 4.60	A = 2.90, B = 3.90, C = 4.80
Track, F/R (m)	1.64/1.64	1.44/1.44
Length (m)	A = 4.25, B = 5.20, C= 6.10	A = 4.60, B = 5.70, C = 6.70
Width (m)	2.02	1.90
Height (m)	2.02	1.90
Ground Clearance (m)	0.20	0.15
Overhang, F/R (m)	0.81/0.81	0.96/1.01
Fuel capacity (range, in km)	425	375
Chassis & Body		
Layout	front engine/front drive or rear engine/rear drive	front engine/rear drive
Body/frame	full frame, steel rails	semi-monocoque
Brake System		
Front	disc	disc
Rear	drum	drum
Power assist.	vacuum or hydraulic	vacuum or hydraulic
Brake swept area (cm^2/kg)	1.4	1.0
Wheels	14" x 5"	13" x 5"
Tires	radial ply	bias ply
Steering type	power assisted	unassisted
Turning circle curb to curb (m)	A = 12.13, B = 16.0, C = 20.0	A = 14.3, B = 18.0, C = 22.0
Front suspension	independent	independent
Rear suspension	independent	non-independent
Engine		
Type	diesel or propane	gasoline
Power (kw/kg)	0.048	0.035
Fuel requirement	diesel or propane(2)	gasoline
Alternate fuels	conversion via retrofit	factory converted
Emission control	to meet CMVSS 1101, 1102, 1103, 1104, 1105	to meet CMVSS 1101, 1102, 1103, 1104, 1105
Availability	3 years experience in the field	new engine

TABLE 4.3 - PARATRANSIT VEHICLE SPECIFICATIONS (continued)

Item	Desirable Level	Acceptable Level
Drivetrain		
Transmission	automatic with torque converter lock-up	Automatic with torque converter, no lock-up
Number of Gear Ratios	3 or 4	2
Instrumentation		
Type	analog or digital	analog or digital
Instruments	speedometer, odometer, fuel level, battery, oil and coolant temp., pressure	speedometer, odometer, fuel level, battery, oil and coolant temp., pressure
Warning Lights	ignition, high beam, door open, parking brake on, oil filter change	ignition, high beam, door open, parking brake on, oil filter change
Accessibility		
Accommodation	easy entry and exit, including wheelchairs - shall be designed to accommodate all individuals between following sizes 95th percentile male to 5th percentile female(3)	easy entry and exit, including wheelchairs - shall be designed to accommodate all individuals between following sizes: 95th percentile male to 5th percentile female(3)
Interior height (m)	1.57	1.50
Seating	easily accessible	easily accessible
Wheelchair ramp		
- angle	12:1 slope, on a 12.7 cm curb	10:1 slope on a 12.7 cm curb
- width	0.90 m with raised sides	0.81 m with raised sides
Handholds	two, adjacent to door	two, adjacent to door
Floor height above ground	0.25 m	0.30 m
Doors		
Width (m)	1.00	0.91
Height (m)	1.44	1.35
Door opening	operates manually with minimum effort	operates manually with minimum effort
Passenger Door location	2 doors each side* (* dependent upon vehicle capacity and configuration)	1 door each side*
Wheelchair Ramp		
Overrunning	ramp edges shall prevent overrunning	ramp edges shall prevent overrunning
Illumination	11 lux over ramp area	11 lux over ramp area
Loading	no permanent deformation	no permanent deformation
Operational mode	manual (or field proven automatic version)	manual or automatic
Wheelchair		
Access	wheelchair entrance and egress with minimum passenger disturbance	wheelchair entrance and egress with minimum passenger disturbance
Orientation	forward facing	angular or rearward
Restraint	meets Ontario O.R. 167/81	meets Ontario O.R. 167/81
Dimensions of Wheelchair	W: to 0.76 m L: to 1.22 m Wt: 250 kg	W: to 0.76 m L: to 1.22 m Wt: 250 kg

TABLE 4.3 - PARATRANSIT VEHICLE SPECIFICATIONS (continued)

Item	Desirable Level	Acceptable Level
Folding and jump seats	manually locked in stowed or deployed position	manually locked in stowed or deployed position
Driver Station		
Anthropometric Accommodation	5th percentile female to 95th percentile male(3)	5th percentile female to 95th percentile male(3)
Fare meter (if applicable)	visible to driver and passengers	visible to driver and passengers
Communications	two-way radio for driver	two-way radio for driver
Driver protection	optional bullet resistant partition between driver and passengers	no partition
Restraint Systems		
Driver	3 point, lap and shoulder (subject to provincial discretion)	complies with CMVSS 208, 209 & 210
Right front passenger	3 point lap and shoulder	"
Rear seat passengers	2 point, lap belt	"
Climate Control		
H/V and A/C	front and rear HVAC	HV only, front and rear
Defrosting	all windows	front and rear windows
Maintenance and Repair	heavy duty components to minimize life cycle costs	heavy duty components to minimize life cycle costs
Service intervals:		
Oil & filter change	10,000 km	8,000 km
Chassis lube	40,000 km	30,000 km
Body components	minimum damage from moderate collisions	moderate damage
Structural configuration	maximum interchangeability of body parts, and easy replacement	limited interchangeability
Service access	easy for engine, drivetrain and suspension	is accessible
Interior	high durability easy to clean easy replacement	high durability easy to clean
Vehicle service	utilize diagnostic equipment for base vehicle	no diagnostic equipment
Federal Standards	shall comply with CMVSS passenger car standards in effect	shall comply with CMVSS
PERFORMANCE SPECIFICATIONS		
Acceleration		
0-65 km/h at curb wt	less than 8 seconds	less than 11 seconds
Fuel Consumption		
EPA Urban	better than 11.2 L/100 km	better than 14.1 L/100 km

TABLE 4.3 - PARATRANSIT VEHICLE SPECIFICATIONS (continued)

Item	Desirable Level	Acceptable Level
Handling		
Lateral acceleration 30.3 m radius	0.6 G	0.4 G
Braking		
Minimum stopping distance from 100 km/h	60.6 m	60.6 m
Pedal effort for 0.5G stop	154 N	500 N
Fade: percent increase in pedal effort to maintain 0.5 G deceleration in 6 stops from 100 km/h	20%	20%
Interior Noise		
Idle in neutral	61 dBA	65 dBA
Full throttle acceleration	90 dBA	95 dBA
Constant 50 km/h	65 dBA	70 dBA

FOOTNOTES

(1) Four doors may not be always necessary, depending on vehicle design, providing adequate access for driver and passengers is provided.

(2) Natural gas is an additional alternative fuel option, however the current state-of-the-art for this fuel is not as advanced as for diesel or even propane.

(3) The terminology "95th percentile male to 5th percentile female" refers to that group of persons falling within those boundaries, that is, excluding the 5% largest males and the 5% smallest females.

5.0 GUIDELINES ON VEHICLE TECHNOLOGY, REGULATIONS AND OPERATION

The successful operation of a paratransit service can be greatly enhanced by co-ordination between the areas of vehicle selection and operation. These two areas are in the domain of the provider of the service, however limitations are imposed by the availability of a suitable vehicle, or vehicles, and the regulatory framework within which the operator must work.

This section presents guidelines that address the three principal areas as follows:

- technology, applicable to the developer;
- regulations, applicable to the legislators;
- operations, applicable to the service provider.

Emphasis is given to the guidelines on technology as it has been determined that the provision of paratransit services are generally not unduly hindered by current legislation, and that operating procedures are, to a large degree dependent upon the service demand, density, city size and numerous other variables.

5.1 Guidelines to the Developer

In this section, guidelines are given for the vehicle developer, in an attempt to ensure that newly developed vehicles are appropriate for paratransit service.

5.1.1 General Requirements

A paratransit vehicle is intended for use in the commercial transportation of passengers, including the elderly and handicapped (including wheelchairs) through demand-responsive scheduling and/or flexible routing. The optimum passenger-carrying capacity depends largely upon the specific application, but it typically ranges from 4 to 12 seated passengers. Ease of entrance and egress for the general public and the elderly and handicapped should be excellent, in order to minimize loading/unloading time and achieve a high level of service. The vehicle interior should achieve a perception of privacy and security in order to compete with the private automobile. The vehicle should have good performance, and low operating costs in order to be attractive to fleet operators. In addition, the vehicle should carry fleet dispatch communication and/or fare calculation equipment. Guidelines on each of the individual aspects of the vehicle are contained in the following sections.

5.1.2 Vehicle Design/Technology

(a) Configuration

One of the prime requirements of a paratransit vehicle is that of a large flat passenger compartment floor, close to ground level to facilitate the loading of wheelchairs. This is best achieved with a front engine/front wheel drive or rear engine/rear wheel drive configuration. For the capacities required, only two axles are required, and the urban application poses no requirement for four wheel drive. Ease of entrance/egress from sidewalks, on one and two way streets, necessitates passenger doors on both sides of the vehicle in addition to the driver's door. The resulting configuration is a two axle, two wheel drive, front engine/drive or rear engine/drive, with passenger doors on both sides of the vehicle.

(b) Capacity

It is apparent that no single vehicle can fulfill the varied demands and requirements of the paratransit market and consequently, it is proposed that a family of vehicles of varying sizes is required, and the following are suggested as adequate to cover the bulk of the service requirements:

VERSION A - capacity 4 to 6 seated passengers or 1 wheelchair plus 2 passengers

VERSION B - capacity 6 to 8 seated passengers or 2 wheelchairs plus 2 passengers

VERSION C - capacity 10 to 12 seated passengers or 2 wheelchairs plus 6 passengers

(c) Vehicle Frame

A full structural frame should be utilized in order to achieve good collision repairability, and minimize structural damage due to corrosion. The present state-of-the-art is centered around steel frames, but graphite reinforced composite frames may be introduced, and would be acceptable in paratransit vehicles, once the repair technology is commercially available.

(d) Suspension/Steering/Braking

Where feasible, the suspension system should be independent to give an improved ride over urban streets. The suspension system should incorporate springs, and heavy duty shock absorbers. If a kneeling suspension is utilized to achieve low floor height for entrance/egress, it should be designed to permit operation under winter conditions which frequently pack suspension systems with snow and ice.

The steering system should be power assisted in order to reduce driver fatigue in urban traffic conditions. The steering geometry should achieve maximum manoeuvreability (i.e., minimum turning circle) consistent with good handling characteristics at all speeds, and low steering wheel input effort.

The service brake system should utilize drum brakes to ensure good stopping performance with minimum fade. Disc brakes are generally operationally superior to drum brakes, however, they do experience higher maintenance costs and are unjustified in purely urban operations with limited high speed stopping requirements. For maximum stopping performance and minimum driver fatigue, the brake system should be power assisted, either from gasoline engine manifold pressure, or from power steering pump hydraulic pressure.

(e) Power Plant

The prime requirements for a paratransit vehicle engine are:

- adequate performance (torque versus speed)
- good fuel economy
- limited fuel sensitivity
- good convertibility to alternate fuels
- good durability and reliability
- good maintainability
- emissions certification
- low life cycle costs
- good low temperature ignition and driveability

The engine best meeting these requirements, with the exception of fuel convertibility, is the present high speed automotive diesel, in turbocharged form. On the basis of lower first cost and fuel convertability, the present gasoline automobile engine is superior, but will typically consume 30 to 40% more fuel under urban driving conditions. If a gasoline fueled engine is utilized, it should utilize electronic ignition and electronically controlled fuel injection, with either individual cylinder injectors or a throttle-body injector system.

(f) Drive Train

In order to minimize driver fatigue in urban driving, a fully automatic transmission should be utilized, with three or four speeds depending upon the design of a particular vehicle. A transmission with an input torque converter and planetary gearing is recommended, and torque converter lockup in high gear is advantageous in improving fuel economy. The type of drivershaft/differential axle assembly utilized is largely dependent upon whether the vehicle is front or rear axle driven. Drive ratios should be selected to give good gradeability/acceleration performance, without compromising overall fuel economy.

(g) Body

The functional requirements for a paratransit vehicle body include the following:

- low weight for good payload and fuel economy
- good damage resistance - minor collisions
- good repairability - major collisions
- good corrosion resistance.

Based upon repairability considerations, both steel and glass-reinforced fibre bodies are acceptable. Repairability can be greatly enhanced by means of easily replaced body panels, and damage resistance in minor collisions can be improved by a resilient perimeter bumper system, of adequate cross-section, located at the appropriate height. The body should incorporate wide passenger doors on both the curbside and roadside in addition to the driver's door. Easy access should be provided to both the luggage area and also to the engine for maintenance purposes. In order to permit the loading of wheelchairs, the curbside passenger door should be fitted with a ramp system, either manually or automatically deployed. This ramp, when deployed, should have a slope no greater than 12:1 when the vehicle is adjacent to a 12.7 cm curb. The ramp should have a width of at least 0.69 m, with raised edges, and should be covered with an anti-skid surface. The door width should be no less than 0.91 m, and preferably 1.0 m, with minimum height of 1.35 m, and preferably 1.44 m.

(h) Interior

The passenger compartment of the vehicle should have interior headroom of 1.47 m, and should have a flat floor area for wheelchairs, with a floor height of 0.3 m above street level. The passenger area should be fitted with adequate fixed and folding seats to meet the seated and combination seated/wheelchair capacity requirements. Side and rear windows should be provided to yield a good view of the vehicle surroundings.

The driver's compartment should contain a vertically and horizontally adjustable commercial quality seat for the driver, meeting the following requirements:

- proper ergonomic relationship with all controls and instruments

- positioned so as to perceive and respond to all components of the driving task

- ease of entry and egress

- ease of observation and communication with passengers

- minimization of fatigue
- easy access to dispatch/communication and fare computation equipment.

The driver's console should contain all instruments necessary to monitor the engine and auxiliary systems in addition to the controls necessary for the operation of the vehicle.

For reasons of privacy and security, a transparent bullet-resistant screen should be fitted between the driver and passenger compartments. The screen should permit easy communication plus the passage of currency, tickets, or tokens to pay for the fare.

Adequate storage space for luggage should be provided within the vehicle interior, either in a trunk, or adjacent to the driver's position. A roof rack should be provided for occasional excess baggage.

Interior paneling and liners should be rugged and easily cleaned. Adequate interior lighting should be provided to facilitate entrance and egress under poor ambient lighting conditions.

(i) Climate Control

In a paratransit vehicle, which frequently transports elderly and handicapped passengers, adequate heating, ventilation and air conditioning (HVAC) capacity is essential. Vents and HVAC outlets should be placed to avoid drafts directly on the passengers. Adequate air flow is important, particularly in the case of respiratory problems. Due to the different HVAC demands within the driver and passenger compartments, a separate air delivery system should be utilized for each compartment.

(j) Restraint Systems

For designated seating positions, passenger restraint sytems complying with the appropriate CMVSS regulations should be fitted. Wheelchair restraint systems should be supplied that are in compliance with Ontario O.R. 167/81, (Vehicles for the Transportation of Physically Disabled Passengers) or other appropriate provincial or municipal regulations.

5.1.3 Vehicle Performance

(a) Acceleration

The paratransit vehicle should be designed so as to produce an acceleration time to 65 km/h, at curb weight, of 8 to 11 seconds, in order to possess adequate gradeability and facilitate passing and merging in congested urban areas.

(b) Fuel Economy

The paratransit vehicle should achieve a fuel consumption rate of 11.2 to 14.1 litres per 100 km when operated on the EPA urban driving cycle.

(c) Braking

The paratransit vehicle should achieve a maximum stopping distance of 60.6 m from a speed of 100 km/h, with minimal fade on repetitive stops.

(d) Handling

The paratransit vehicles should have the following curb-to-curb turning circles:

	Desirable	Acceptable
VERSION A	12.13 m	14.3 m
VERSION B	16.0 m	18.0 m
VERSION C	20.0 m	22.0 m

Steering effort, both vehicle stationary and at speed should be no greater than a typical passenger car.

Ride comfort should be equivalent to a full size passenger car.

5.1.4 Vehicle Safety

The PTV must comply with all CMVSS regulations in effect for the appropriate classification: passenger vehicle, multipurpose passenger vehicle or bus. Compliance should be achieved by using certified components where possible or by testing prototype and/or production vehicles.

5.1.5 Production

The developer should be aware of the limited demand for paratransit vehicles, and design the vehicle around appropriate materials and processes, without extensive tooling. As of 1982, the estimated U.S. market was 5,000 vehicles per year, and a Canadian market estimate of 500 vehicles per year appears realistic.

5.1.6 Service and Maintenance

In order for the paratransit vehicle to gain wide acceptance, a service infrastructure should be provided. This could be most easily implemented by a cooperative agreement with an existing or specialty vehicle manufacturer network, corresponding to the supplier of major vehicle systems, such as the propulsion system.

The vehicle should be durable and reliable in material and workmanship with a design life of 5 years or 500,000 kilometres and offer maximum protection from corrosion. The vehicle should have the following features to enhance its maintainability:

- easy access to major system components
- maximum utilization of commercially available components
- oil and filter change interval - 10,000 km
- chassis lubrication interval - 40,000 km
- preventative and corrective maintenance to be performed with a minimum requirement for special tools.

5.1.7 Cost

In order to be competive, the paratransit vehicle must have a purchase price comparable to and a life cycle operating cost lower than competitive vehicles. A purchase price premium of more than 50% above competitive vehicles will greatly reduce paratransit vehicle market penetration, in spite of lower life cycle costs.

Due to the high purchase cost of paratransit vehicles, it is essential that their life cycle costs are significantly less than competitive vehicles, or they will not become commercially viable.

5.2 Guidelines to the Regulator

The degree to which regulations can be, or should be, modified for any reason must take into due consideration the original objective of the regulation. In effect, in the case of a disparity, should the vehicle be modified to fit the regulations or should perhaps the regulations be changed to permit utilization of a new vehicle?

The Government of Canada, through the Federal Motor Vehicle Safety Act, is responsible for vehicle safety. Under certain specific circumstances an exemption may be granted to compliance with Canadian Motor Vehicle Safety Standards. One of the cited grounds for a possible exemption is a situation whereby compliance with the Standards would prevent the development of new kinds of motor vehicles and motor vehicle systems and components. In view of the inclusion of this clause and the basis of the Standards (to ensure safety) it is considered that Federal regulations do not require any modification or reconsideration that would facilitate paratransit operators.

Provincial regulations principally affect areas such as permitted vehicle weights and dimensions and requirements for safety inspections. No areas under provincial jurisdiction have been identified that currently provide a hinderance to the provision of operation of a paratransit service, and thus no modifications are required.

Municipal legislators are those most often determined whether or not an innovative service (such as paratransit), or a new vehicle design, or a combination of the two can operate. It is necessary for municipalities to have control over services such as taxi (and therefore paratransit) operations - this is not disputed - however the implementation of the regulations in place must be realistically undertaken. A particular case in point is where a municipal bylaw (or, in the case of Quebec, the provincial regulation) states that a taxi should have four doors. A regulation of this type was probably initially brought in to prohibit the use of vehicles where access to the rear seat was by means of the door adjacent to the front seat, which folded forward. Strict adherence to this regulation would, however, prohibit the use of a vehicle such as the McFarland Design Paratransit Vehicle, which has only three doors.

The municipal regulations may prohibit or hinder paratransit operations by either adversely affecting use of a new vehicle type, as per the example above, or by influencing the mode of operation to such degree that the paratransit service is not viable in the form envisaged by the operator.

Shared ride travel by taxi is prohibited in most municipalities in North America. This regulation can, in many instances be contrary to public interest in that multiple trips are required where one may have sufficed and been acceptable to the occupants.

Municipal regulations regarding the provision of taxi and/or paratransit services must be reviewed either prior to or upon enquiry respecting provision of a paratransit service. Outdated regulations should not be strictly adhered to without having reaffirmed their applicability. Particular areas of concern are the following:

- legislation respecting permitted vehicle types and/or body styles;
- legislation affecting the number of persons permitted to travel in a vehicle, which is often limited to fewer than the capacity of paratransit vehicles;
- legislation respecting the provision of shared ride services;
- legislation respecting tariffs and fare compulation,which is often precisely regulated in association with the regulations concerning shared ride services.

With the continually increasing price of gasoline, the public will, at some stage, start to reduce expenditures on travel. For those who rely, in large part, on taxi or paratransit services the only option is to reduce their frequency of service utilization. The most apparent means by which this reduction in level of utilization can be achieved is by reducing the cost of individual trips by:

- implementation of shared ride services,
- utilization of purpose designed vehicles.

Although some municipalities have made progress in the revision of regulations regarding taxi licensing and regulation, in some instances these changes have been in the right direction but have not gone far enough. For example, the City of Vancouver applies a license fee to a cab that is used exclusively for transporting passengers confined to wheelchair that is $30 less than the fee for a conventional cab. It is suggested that a more appropriate definition for the vehicles to which this reduced rate should be applicable is vehicles that are capable of carrying one or more passengers in a wheelchair.

Apart from the possible contravention of existing municipal bylaws, and thereby the initiation of a regulatory conflict with the municipality, a dispute may be initiated by the provider of an existing transportation service. Historically there have been a number of for hire transportation services that have generally been recognized, either implicitly or explicitly, by appropriate regulating authorities. These have included:

- school bus service
- airport limousine
- ambulance
- contract services
- charter services
- taxicab services
- mass transit.

Paratransit regulatory disputes have been almost variably rooted in the relative definitions of taxicab service and mass transit service and into what niche does paratransit fit. Taxis and mass transit, as the two established poles in the relatively recently identified range of public transportation services, both represent powerful vested interests with immediate concerns over the future direction and control of paratransit. In the context of paratransit services, which reflect a merger between the extremes of conventional transit and taxis, the definitions and applicable regulatory framework tend to be ambiguous and overlapping.

Figure 5.1 indicates the regulatory conflicts that commonly occur between conventionally regulated services and a selection of new paratransit services. A review of these potential conflicts follows.

FIGURE 5.1

REGULATORY CONFLICTS BETWEEN CONVENTIONALLY REGULATED TRANSPORTATION SERVICES AND NEW PARATRANSIT SERVICES.

New Paratransit Services	Conventionally Regulated Services				
	Limousine	Ambulance	Contract	Taxicab	Transit
Medicab		X		X	X
Shared ride taxi	X			X	X
Dial-a-ride				X	X
Off-peak/feeder services			X	X	X
Human Service Agency providers		X		X	X

Medicab. The non-ambulatory, especially those confined to wheelchairs are generally unable to use conventional transit services if certain taxi companies have special lift equipped vehicles, these can be used. If this is the only mode of transportation available it must fulfill a wide range of needs than it does for other citizens. Thus special paratransit services for the non-ambulatory (generally termed 'medicab') have been established in many cities. The service may be provided by a private taxicab operator or by other public, for profit or non-profit organizations. Because of the wide range of needs of a diverse clientele which lack other public transportation options, the service provided may take on characteristics of fixed route service, conventional taxi service, or anything in between. The possibility is therefore open for conflicts with the conventional public or private operators, possibly involving separate regulatory authorities, such as health departments.

Shared ride taxi. Shared ride taxis often face regulatory resistance from taxi regulatory authorities. This resistance may be supported by certain segments of the taxi industry itself. Shared ride and other innovative concepts may be resisted because of a fear of adverse impacts upon the industry or, possibly, the riding public. To some extend this concern may be justified because, if an appropriate fare structure does not accompany approval for shared ride service, serious problems may arise. Unfortunately uncertainties as to how an equitable fare structure can be assured is often a deterrent to shared ride experimentation. Previous experience with a cumbersome regulatory process that is slow to respond to needed fare structure adjustments is likely to discourage operators from being willing to take a risk with an innovative service the rewards from which are uncertain.

Dial-a-ride. Dial-a-ride services represent a hybrid between two well defined existing services, and may be subject to regulatory conflicts with both, depending upon who may feel threatened by a particular operation. The question of who should regulate the new service is important in that the operating rules will influence how the new service complements or competes with various existing modes. For example, the taxi industry may be interested in seeing the new service controlled under their regulations in order to protect their service from what they perceive as undue competition.

Off-peak/feeder services. Off-peak subsitute and feeder services provided by either conventional taxis or modified vehicles are being tried in many cities in an attempt to augment transit services and make them more cost effective. The intent of these services is to bridge a gap between taxi and transit modes, to the benefit of both. However, the services can take on characteristics of both modes and may be subject to claims of responsibility of transit regulations, taxi ordinances or both. Resolving the problem of establishing a service that by definition is attempting to serve two masters, may delay if not completely prevent successful implementation.

Human service agency providers. Many service agencies receive funding to provide transportation services in addition to social service work. These services have grown significantly in recent years. Since these services are usually provided without charge to the passenger the agencies contend that their service does not fall within any regulatory guidelines. However, as these services expand they create a greater impact upon ridership of conventional modes and this has provided for a basis for court action in some instances in the United States. Ambulance, taxi and transit interests may be involved. In each instance the offended carrier will claim that the agency service is competitive and hence illegal as it is not in conformity with the carrier's own regulations.

The above examples serve to demonstrate the potential of regulatory confusion surrounding the introduction of new paratransit services. Most of the regulations were promulgated at least two decades ago in an era when transportation needs were very different.

A generally less mobile society, coupled with a heavy dependence on the private automobile and a relative lack of social concern for the transportation needs of the poor and the disabled, led to a transportation supply that consisted of a very few, clearly distinguished alternatives. These were generally limited to fixed route transit, exclusive-ride taxi, school bus services, charter services, contract services, and some of the other specific services, such as ambulance and airport limousine.

As the transportation needs of an increasingly mobile society have grown, so have the problems of pollution, congestion, energy consumption, and the awareness of the isolation of the disadvantaged. Increasingly flexible responses are needed, and so conventional modes suffer from inadequacy at the same time that there is a push for new services. Thus, that conventional providers of service are often struggling to protect an increasingly unprofitable existence at the same time that demand for a range of new competitive services is becoming apparent. Their response takes the form of either trying to prevent the new service or trying to assume the right to provide it.

This struggle is complicated by the hybrid nature of most new services. In most cases, at least two different conventional sectors have some basis for an active interest in the new service. This interest may be based on either of two claims:

- The new service shares characteristics of an existing mode which render it subject to regulation by the same authority that controls the existing carrier;
- The new service will be or is sufficiently competitive with the existing mode to cause an adverse impact on ridership and revenue, and should therefore be subject to regulations designed to protect existing carriers.

Carriers affected by a new service have an interest in having that new service regulated, and in particular they are interested in seeing it regulated by their "own" regulatory authority rather than by a different authority.

An existing carrier may even want the right to provide the new service. Prospects for this can be determined by establishment of an appropriate regulatory authority. However the hybrid nature of many new services may continue to generate confusion in an environment where no specific regulations have been designed to respond to the nature of the new service. When responsibility for a new service is assigned to a regulatory authority, that authority frequently attempts to define the new service within the context of conventional services. This has the effect of tying the new service to many of the structures that constrain existing services. If the new service is not actively defined, on the other hand, then confusion will remain as to the basis for regulation of the new service. Thus, for example, a shared ride contract with a human service agency may be argued to be authorized under taxi certification, under contract carrier authorization, or not covered by any regulations at all.

The only way to end this confusion is to define new services in their own right. This must be accompanied by specific rules applicable to the new service as appropriate. Details which must be included for each type of service are: driver and equipment requirements, the method of operation, the basis of fares or charges, and reporting and other general requirements.

In the mid and late 70's the United States government actively promoted wider use of taxicab services and introduction and expansion of paratransit services. A quotation from the Federal Register, October 20, 1976, 41(204), is as applicable to Canadian municipalities now as it was to their Amercian counterparts at that time:

> "Outmoded local laws, regulations and ordinances often constitute a barrier to paratransit implementation. Local and State agencies are encouraged to review existing laws, regulations and ordinances pertaining to paratransit operation and eliminate or revise obsolete requirements or prohibitions that constrain or inhibit the introduction of paratransit services".

5.3 Guidelines to the Operator

The operator of a paratransit service must make a number of important decisions prior to implementation of the service, in order to ensure its viability and efficiency. The principal areas to be covered are:

- assessment of the market
- fleet size and composition
- vehicle selection
- ancillary systems
- vehicle maintenance

5.3.1 The Market

The extent of the potential market and its characteristics must be clearly identified prior to establishment of the operating characteristics of the system. Due in part to the current scarcity of transportation services catering to the mobility disadvantaged the extent of this sector of the population is often not evident. Data may be available from certain social service agencies. For services that are not limited to disabled persons, but rather are capable of carrying both ambulatory and wheelchair passengers, an assessment must be made of the extent of the disabled market in order that the vehicle requirements and vehicle fleet composition may be determined.

Should a potential market be identified that appears sufficiently large to support a new service, the ease of access to the taxi/paratransit industry must be considered. The less the degree of specialization and the greater the degree of competition with existing taxi operators, the greater will be the difficulty in establishing a new service. This will particularly apply to larger metropolitan areas, however it is these centres in which the greatest market potential is to be found. Access to the conventional taxi business is generally both costly and strictly regulated. Establishment of a strictly paratransit service would likely be acceptable to many taxicab operators, however competition with taxis will necessitate adherence to the marketplace rules. It may be that the premium on the vehicle price for a paratransit vehicle, coupled with the expense of market penetration, may be too severe a financial load to be offset by the relatively small increase in potential fare paying passengers obtained by providing a service to the non-ambulatory. The cost of entering the competitive market must be assessed as clearly as the potential for providing a service.

In determining the transportation requirements of the disabled sector of the population their specific trip requirements must be considered. Origin-destination patterns and regularity of trip making may not be consistent with the mobile sector and therefore the use of appropriate factors, in determining the market, is essential.

In entering the market with a paratransit service that offers trips both in competition with existing taxi service in addition to paratransit services for the disabled, on appropriate means may be to associate as affiliate with an existing major operator. This may provide a means of entering the marketplace, for the paratransit operator, while at the same time expanding the services of the taxi operator at little or no financial risk to him. Significant benefits may also be gained through utilization of already established servicing facilities and dispatch and communication networks.

5.3.2 The Fleet

The size and composition of the fleet are important factors. There are advantages in a large scale operation, that is, establishment of a paratransit service with only, for example, fifteen vehicles is less efficient than a service with fifty vehicles. Obviously, the fleet size is dependent upon the demand for the service, however where demand for such a specialized service is less than for a minimum of thirty vehicles the system will face economic hardships. The day of the small taxi operator is fast disappearing and a taxi is a less costly vehicle to purchase than a paratransit vehicle. Again the advantages of association with an existing taxi operation are apparent in fleet size selection as the established conventional taxi operation can be utilized by the paratransit vehicles when not carrying wheelchair passengers.

The paratransit fleet should be as homogeneous as possible to reduce maintenance and parts costs. Where feasible vehicles of different capacities should be obtained from the same manufacturer.

5.3.3 Vehicle Selection

Until recently there were no vehicles specifically made for paratransit service. The major automobile manufacturer contend that the market is of insufficient size, consequently, those vehicle now becoming available are generally produced by specialist manufacturers. The range of available vehicles is not large within any specific capacity range and therefore choice is limited. The vehicle specifications presented in this report may be utilized as an aid in selecting a vehicle, especially in the area of performance characteristics. To a large degree the vehicle selection process is based on individual preference, however, due consideration should be given to features such as vehicle repairability and low operating cost, in order to reduce downtime and increase profits, and increase service reliability. In cases where a paratransit fleet is comprised of vehicles capable of carrying wheelchair passengers as well as conventional vehicles, the selection of those in the latter category should be carefully made. The use of small vehicles should be avoided because, even though they may exhibit lower operating costs, capacity constraints limit their effectiveness for use in the 'shared ride' mode.

5.3.4 Ancillary Systems

Vehicle control and dispatching systems are of extreme importance. An efficient communication system leads to maximization of efficient use of the vehicle. Significant advances have been made in recent years with computer dispatch systems and computer aided systems. These systems offer distinct advantages over conventional radio communication systems, the principal advantage being speed and efficiency. One advantage particularly relevant to provision of paratransit services is the volume of information that can be input into the system for relay to a driver with respect to answering a specific call. Using conventional dispatch methods limits the amount of time the dispatcher can spend in communication with any one driver, to the detriment of provision of a paratransit service where specific instructions may be required.

The initial setting up of a control and communications system is an expensive capital investment at the establishment of a new service, and the cost is fairly fixed regardless of fleet size. Utilization of an existing system by joining with a current operator would avoid the majority of these costs.

Fare computation equipment is generally a necessary addition to the vehicle, especially if duty is both conventional taxi and paratransit oriented. The larger the vehicle capacity, occasioned by provision for wheelchairs, the greater the requirement for high capacity utilization and therefore a system of ride sharing. Deviations from exclusive ride characteristics require modification to the conventional meter fare computation system. Modern electronic meters can be programmed for a varying number of different fare structures. Such meters would appear to be appropriate in vehicles that offer both conventional taxi and paratransit services and, due to their larger than average size, would benefit from shared ride utilization.

5.3.5 Vehicle Maintenance

An effective preventative maintenance program, incorporating specific procedures on a regular interval, should be utilized to prevent malfunctions and breakdowns.

Both preventative and corrective maintenance may be handled in several different ways depending upon the size and nature of the fleet operation:

(a) Contract maintenance out to commercial sources, such as garages, service stations, etc.

(b) Contract maintenance out to other agencies such as city garages, or school bus operators.

(c) Set up an 'in house' maintenance facility.

(d) Carry out basic maintenance work 'in house' and contract out overload work.

If the work is carried out 'in house' the operator should ensure that the facility and equipment are adequate.

A maintenance schedule should be developed including daily checks, monthly checks, and regular checks at predetermined vehicle mileages. The daily check should be carried out prior to the operation of the vehicle, and at the end of the day the driver should file a record of any observed malfunctions/deficiencies.

The regular preventative maintenance procedures and schedules should be followed to avoid reductions in vehicle reliability, longevity, and warranty coverage.

Maintenance records should be kept for each vehicle, and updated after each maintenance action.

A phased program of vehicle replacement should be built into the maintenance program.

5.3.6 Operating Costs

The establishment of a comprehensive maintenance program will go a long way in reducing operating costs. It is important to be able to identify where the operating costs are, in order that reductions in these costs can be attained. For this reason a detailed breakdown by expense item is required. Principal areas of expenditure are identified in the following list:

- driver labour
- driver fringe benefits
- non-driver wages and salaries
- non-driver fringe benefits
- other services (security, maintenance, etc.)
- non-personal services (utilities, advertizing, etc.)
- materials and supplies (fuel, oil, tires, parts)
- insurance and claims
- leases and rentals
- non payroll taxes and fees (licences, business tax, etc.)
- interest
- depreciation (on vehicles, meters, furniture etc.)

The key to keeping operating costs down is to run an efficient operation, and that includes knowing what costs are allocated to what areas and the identification of potential areas for cost reduction.

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PARATRANSIT VEHICLE TECHNOLOGY:
GUIDELINES FOR REGULATORS, OPERATORS AND VEHICLE DEVELOPERS

SUMMARY REPORT

Prepared for
Transportation Development Centre

by

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May, 1982

The contents of this report reflect the views of the contractor and not necessarily the official views or policies of the Transportation Development Centre, Transport Canada.

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17 Abstract

The objective of the report is to provide those concerned with the design, regulation or operation of paratransit services with guidelines to enable them to more effectively provide an efficient vehicle or system.

Paratransit has been described as a bridge between the conventional auto and conventional transit and includes such operating modes as hire and drive services, hail or phone services and pre-arranged ride sharing services. Vehicles currently in use for paratransit services include passenger cars, special taxi vehicles, standard and modified multipurpose vehicles (vans) and small buses.

Two principal services offered by paratransit and addressed in this study are:

(1) a high-quality alternative to the automobile through trip-sharing;

(2) mobility for the elderly or handicapped, with particular emphasis being placed on the latter.

The study is presented in four sections, including: assessment of currently available vehicles; legislation affecting design and service of vehicles; acceptable and desirable vehicle specifications based on user and operator requirements; and guidelines itemizing areas of concern as an aid to ensure establishment of viable taxi/paratransit operations.

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17 Resume

Le rapport vise à offrir aux parties impliquées dans la conception, la réglementation ou l'exploitation de services non conventionnels de transport collectif une aide technique pouvant servir à améliorer les véhicules ou les systèmes.

Les transports collectifs non conventionnels incluent toute une gamme de modes allant de l'auto conventionnelle jusqu'au transport collectif conventionnel. Ils incluent aussi plusieurs types de services tels que les services de location, les services hélés ou réservés par téléphone et les services de covoiturage conclus à l'avance. Les véhicules utilisés présentement pour ces types de services incluent les voitures particulières, les véhicules taxi spéciaux, les camionnettes avec ou sans modifications et les minibus.

Deux types de services offerts par les transports collectifs non conventionnels et visés par ce rapport sont les suivants: (1) offrir une alternative de haute qualité aux voitures particulières par l'entremise du covoiturage et (2) assurer la mobilité des vieillards et des handicapés; avec emphase particulière sur ce dernier.

Le rapport est présenté en quatre sections comprenant: l'évaluation des véhicules existants, la réglementation touchant à la conception et à l'exploitation des véhicules, les spécifications acceptables et désirables pour les voitures en fonction des exigences des utilisateurs et des exploitants et les normes suggérées d'exploitation afin d'assurer un service viable.

18 Mots-clés
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FOREWORD

Project Background

The project entitled "Paratransit Vehicle Technology: Guidelines for Regulators, Operators and Vehicle Developers" was initiated by the Transportation Technology Committee of the Roads and Transportation Association of Canda (RTAC). Impetus for the project was provided by the considerable interest generated by the GSM Taxi, which was displayed at the RTAC Conference in Toronto in September 1980.

The Transportation Development Centre of Transport Canada agreed to fund and carry out the study. The Terms of Reference were generated in February, 1981 and requests for proposals issued in March. The project was subsequently awarded to DeLCan (De Leuw Cather, Canada Ltd.).

Project Objectives

The principal objective of the study is to enable a document to be prepared, for dissemination by RTAC, that will provide those concerned with the design, regulation or operation of paratransit services with guidelines to enable them to more effectively provide for an efficient vehicle or system. It is intended that, by means of these guidelines, a degree of standardization may be attained in the areas of vehicle design and operational structure for taxi and paratransit services.

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1.0 INTRODUCTION

The project entitled "Paratransit Vehicle Technology: Guidelines for Regulators, Operators and Vehicle Developers" was undertaken by DeLCan (De Leuw Cather, Canada Ltd.) on behalf of the Transportation Development Centre, Transport Canada. The main report (TP 3648E)(1) discusses paratransit operating modes and examines, in significant detail, paratransit vehicles in service and in development.

This summary report (TP 3690E) is rather more of an abridged version of the main report than a summary. This is due to the nature of the topic - guidelines and specifications cannot realistically be summarized. This report thus includes appropriate sections of the main report and excludes those sections that are of a more technical nature and consequently of less immediate interest to those persons involved in regulation, operation or vehicle development for paratransit services. Reference should be made to the main report (TP 3648E) for further details.

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(1) Reference 1

2. VEHICLE ASSESSMENT

2.1 Taxi and Paratransit Operating Modes

Historically taxicabs have provided an exclusive door-to-door transportation service for either single passengers or pre-formed groups. A multitude of regulations, principally designed with regard to safety, service levels and fares, have effectively prohibited operators from providing a service that deviates from the standard door-to-door exclusive trip.

Within the last decade a number of transportation developments have combined to stimulate interest among policy makers and these have resulted in a re-evaluation of the traditional policies regarding taxicabs. One of the major instruments of change has been the increased awareness of the requirements of the transportation disadvantaged, and the ensuing legislative directives requiring that special efforts be made to provide improved transportation services to those unable to use conventional fixed route transit services.

Paratransit has been described as a bridge between the conventional auto and conventional transit. Prior to the growth of paratransit, the only options available for urban transportation were personal automobile, exclusive ride taxi or conventional transit. Of the numerous existing paratransit concepts, some have developed from the automobile end of the spectrum (such as variations of the taxi service, and carpooling), while others have been developed from the other extreme, such as subscription bus services and dial-a-ride.

This section provides data on many of the taxi and paratransit operating modes in use and examples of their implementation.

Paratransit services can be grouped as follows:

(a) hire and drive services

(b) hail or phone services (demand responsive)

(c) pre-arranged ride sharing services

Figure 2.1 provides data on the general service characteristics of a number of paratransit modes. These modes all, as previously mentioned, fall between the conventional auto and transit modes, and are arranged in the order corresponding to their similarity in service characteristics.

The three categories of paratransit service are indicated at the top of the table. There is, however, considerable variation within each of these categories with respect to possible service levels, ownership, operation and regulation. The table serves a purpose in simplistically indicating paratransit general characteristics.

FIGURE 2.1
PARATRANSIT: GENERAL SERVICE CHARACTERISTICS BY MODE

	Para-transit Modes							
		Hire and drive services	Hail or phone services			Prearranged ride-sharing services		
	Private auto	Daily and short-term rental car	Taxi	Dial-a-ride	Jitney	Car pool	Subscription bus	Conve tiona transi
Direct route (DR) or route deviations (RD)?	DR	DR	DR	RD	RD	RD	RD	RD
Door-to-door?	Yes	Maybe	Yes	Yes	No	Yes	Maybe	No
Travel time spent as passenger (P) or driver (D)?	D	D	P	P	P	P/D	P	P
Ride shared (S), or personal (P)?	P	P	P/S	S	S	S	S	S
System routes fixed (F), semi-fixed (S), or variable (V)?	V	V	V	V	S	S	S	F
Access determined by prior arrangement (A), fixed schedule (F), phone (P), street hailing (H), or at user's discretion (U)?	U	U	H/P	P	H	A	A	F
Vehicle parking required (PR) or not (NP)?	PR	PR	NP	NP	NP	PR	PR/NP	NP
Convenient for baggage?	Yes	Yes	Yes	Maybe	Maybe	Maybe	Maybe	No

Source: Reference 2

It should be noted that the same vehicles can provide different services at different times, if the regulatory framework permits. For example, a taxicab can provide regular taxi, dial-a-ride, jitney and subscription services when the regulations include suitable fare and service standards for these different services. Figure 2.2 indicates general markets for paratransit services.

The hire and drive services, generally in the form of short-term or daily car rental, will not be further considered in this report as they are generally not included in the same legislation as other taxi and paratransit modes.

Conventional Taxi: The conventional taxi service is a demand responsive exclusive service. The taxi can be summoned either by telephone or curb hailing, generally only carries one person or a prearranged group, and provides door-to-door service without detour or intermediate stops.

Dial-a-ride Service: This service is a shared ride taxi service summoned by telephone, where new calls may be responded to while the vehicle is in use by other passengers. This service is therefore inferior to a regular taxi service in that it may involve a route deviation and therefore add a time penalty for arrival at the destination. The system offers potential cost savings resulting from increased vehicle occupancy. The dial-a-ride service received close attention in the United States in the 1960's though some taxicab operators had been providing this service for some time. Many experimental dial-a-ride services using small buses and vans were tried out in the 1960's and 1970's. The findings were generally that per-passenger costs were high and demand densities low. The focus of attention changed to the taxicab operators as a potentially more cost-effective provider of dial-a-ride services. A number of taxicab companies now provide publicly funded dial-a-ride service either for the general public or for special user groups, such as the elderly and handicapped.

The following cities have instituted dial-a-ride services for the general public:

City	Number of Participating Taxicab Companies
El Cajon, California	one
Fullerton, California	one
Westport, Connecticut	two
Hopkins, Minnesota	one
Cadillac, Michigan	one

FIGURE 2.2
GENERAL MARKETS FOR PARATRANSIT SERVICES

	Para-transit Modes						
	Hire and drive services		Hail or phone services			Prearranged ride-sharing services	
Demand characteristics	Daily Rental Car	Short-Term Rental Car	Regular Taxi	Dial-a-Ride and Hail-a-Ride	Jitney	Car Pool	Subscription Bus
Spatial (location/trip length)	• Airport access • All types	* All types	• Short trips • CBD oriented • Airport access •* Small cities * Line-haul feeder	•* Short trips •* Intrasuburb •* Intersuburb * Intra-CBD * Small cities •* Line-haul feeder	•* Tourist corridors * Home-to-work corridors * Business/commercial corridors	•* Long trips •* Home-to-work corridors * Line-haul feeder	•* Long trips •* Home-to-work corridors * Line-haul feeder
Temporal	• All hours	* All hours	• Midday 10 A.M.-4 P.M. •* Early morning/late evening •* Peak hours	•* Midday * Early morning/late evening	* Peak hours * Midday	•* Peak hours	•* Peak hours
Demographic (traveler/trip purpose)	• Out of town visitors • Business trips • Recreation trips	* Residents living in medium to high density areas — all trip purposes	• Professional & managerial workers • Out of town visitors • Housewives shopping • Low income * Limited mobility groups	•* Housewives shopping & personal business •* College students * Business trips * Limited mobility groups	•* Tourists * Workers of all income groups * Business trips * Shopping trips	•* Workers of all income groups •* Shopping in low-income areas	•* Workers of all income groups • School trips

• Present

* Additional potential

Source: Reference 2

Publicly funded dial-a-ride services available to the elderly and handicapped have been started in the following communities:

City	Number of Participating Taxicab Companies
Portland, Oregon	two
Pittsburg, Pennsylvania	three
Danville, Illinois	two
Montgomery, Alabama	fourteen
Kingston, North Carolina	fifteen
Kansas City, Missouri	two

The United States Urban Mass Transportation Administration has expended considerable funds in research, development and demonstration projects for dial-a-ride services, including a demonstration project in Haddonfield, New Jersey, to test operating techniques and public response. Other dial-a-ride systems frequently reported are those in Davenport, Iowa; Ann Arbor, Michigan; Batavia, New York; Rochester, New York; and in Bay Ridges, Ontario (near Pickering) and Regina, Saskatchewan.

Dial-a-ride services can be provided either by taxicab-based systems or by bus- or van-based systems. The majority of the better known dial-a-ride services are bus- or van-based with the exception of Davenport, Iowa. The Royal Cab Company of Davenport operates a 24-hour many-to-many service using about thirty checker cabs, each with a capacity of seven passengers. Although the city does have a privately owned bus company (which is publicly subsidized), the paratransit service provides a significant proportion of the community's public transportation, and is financially self-supporting.

A report by Teal, R.F., Marks, J.V., and Goodhue, R. "Subsidized Shared Ride Taxi Services" (Institute of Transportation Studies, University of California, 1980) provides data on a number of publicly funded projects, principally in California. Contracts have generally been established between a public body and a taxicab company (or group of companies) for provision of subsidized dial-a-ride services to the general public at low fare. The "provider-side subsidy" arrangements contract for specified services to be provided by the service providers, who are reimbursed on the basis of in-service hours, unit of distance or other agreed upon measures.

Taxicab companies are becoming progressively involved in providing publicly funded dial-a-ride services for special user groups. These programs may be supported by specific health care programs or service programs or by a wide variety of funding agencies. "User-side subsidies" are also becoming increasingly popular, whereby the eligible user is provided with tickets or charge slips and encouraged to patronize the service provider of their choice. The provider accepts the token as either whole or partial payment for the trip and obtains reimbursement at pre-arranged rates.

There is a considerable range of variation to be found in publicly funded dial-a-ride services regarding service levels and fares. In general low service levels (longer waits and longer ride times) are consistent with lower fares and the converse also holds true. The choice of which strategy to adopt must reflect overall community objectives. It is noted, however, that in those communities where unsubsidized dial-a-ride services are operated by taxicab companies (such as Little Rock, Arkansas, and Danville, Illinois) the companies provide relatively high levels of service and fares and lower vehicle occupancies. The achievement of higher vehicle occupancies requires costly administrative and dispatching procedures and this expenditure may not be cost-effective.

A variation on the basic dial-a-ride service is a system whereby the paratransit mode serves a feeder function to conventional transit facilities. Probably the three most successful services of this type are the systems instituted in Peterborough, Ontario; St. Bernard Parish, Louisiana; and Bremerton, Washington.

The utilization of existing taxicab fleets, many of which have excess capacity, to complement the transit system is beneficial to the users and to both transportation operators. It is becoming increasingly expensive to operate conventional fixed route transit services and the high costs of operations in areas with low density demand patterns (and consequently low revenues) are difficult to justify. It is for this reason that some transit authorities in large and medium sized metropolitan areas are considering cutting back routes in suburban areas and either eliminating or reducing service in low demand areas, either in off-peak times or totally. A means whereby the transportation coverage is not eliminated is the integration of dial-a-ride, or subscription services, with the fixed route operation. Smaller vehicles can respond to telephone requests, pick up users of the system and drop them off at designated points of transfer to the scheduled transit service. Although this paratransit mode exhibits extensive benefits regarding vehicle operating costs, the combined system of paratransit feeder service and conventional transit does suffer from one important drawback: the system is not fully accessible to handicapped persons as, in most cases, the transit mode is incapable of accommodating their requirements.

The above drawback notwithstanding, a review of the taxicab feeder service mode of operation of paratransit is relevant.

The Peterborough project began as a demonstration project in 1974 providing service to two areas of the city of some 58,000. There was previously a fixed route bus service in one feeder area but the patronage was low and a deficit per passenger was estimated at approximately $2.60. The Trans-cab service was popular and indicated, in 1976, that a lower deficit ($0.88) per passenger was attainable. The city assumed responsibility for the feeder service (following completion of the demonstration project) and provides the municipal share of the operating subsidy. It is worthy of note that the feeder service operator has indicated that the project has had beneficial results for the taxi operator and has stimulated transit use.

On home-to-transit trips the user contacts the feeder service by phone, is picked up and delivered to a transit transfer point. The user pays the total Trans-cab fare to the taxi driver and receives a transfer for the bus portion of the trip. On the bus-to-home trips riders notify the bus driver, upon boarding, that they require Trans-cab service, and pay the fare. The transit driver issues a transfer for the taxi trip and radios the relevant data to the cab dispatcher -bus route number, number of passengers and expected arrival time at the transfer point.

Available data on the Peterborough system indicates that average occupancy per taxi trip declined following the demonstration period and the cost per passenger has increased over time. It was suggested that the cause of the lower occupancy was the development of more dispersed demand patterns and the existing legislation which pays the operator on the basis of distance travelled, and therefore provides no incentive to the operator to increase occupancy. However, average occupancy has increased since 1975. The figures were 1.70 in 1975 and 1.80 in 1976. The 1979 figure was 1.93. Until 1980 each stop was considered a trip, and the occupancy calculated accordingly. In 1980 each meter charge was considered a trip (thereby decreasing the number of trips) and the average occupancy was 2.73.

The municipal authority and the operator do not perceive that the lack of a direct incentive to the operator to increase occupancy is a problem. In practice the dispatchers do arrange for shared trips where this is possible and therefore the utilization of a system whereby the operator was paid on a per passenger basis (instead of per unit distance) would not achieve significant benefits. Furthermore, the adoption of a new system of payment would cause considerable hardship to the operators who are not geared for such a radical change. A comparison of operating statistics for the Trans-cab operator between its early years of operation and 1980 are indicated in Table 2.1.

The St. Bernard Parish (Louisiana) taxicab feeder service is another example of a successful paratransit service but with very different reasons for its initiation.

Until 1973 there had been both bus and cab companies operating in St. Bernard Parish. In 1973 the last of the bus operators closed and in the period during which there was no bus service the taxicab business also suffered a decline. Although this is intuitively not rational, it is apparent that many trips that were previously made partly by bus and partly by taxi were now not made at all. The municipal government considered implementation of a bus service, however, a study indicated that the area could best be served by a combination of regular bus service and a dial-a-bus system. This system would cost more than the area could afford thus meaning that the local government would have to operate the system. As a result of these problems the taxicab company decided to establish a bus operation. It was found that cutbacks in the number and length of routes, in an attempt to keep the system viable, caused an uproar from residents in areas where service was discontinued. It was apparent that many areas of the community required some level of service but that the bus service could not economically extend into these areas. The solution to the problem was remedied by the decision to utilize taxis to bring the residents of the outlying areas to the new bus

TABLE 2.1
TRANS-CAB STATISTICS FOR 1975, 1976, 1977 AND 1980

	1975	1976	1977	1980
1. Total revenue received ($)	19,425.35	24,789.24	29,658.63	50,036.60
2. Total cost ($)	61,264.10	94,970.80	112,531.00	128,009.63
3. Total deficit ($)	41,840.75	70,181.56	82,962.37	77,973.03
4. Total number of passengers	65,574	79,908	96,797	110,812
5. Deficit per passenger ($)	0.63	0.88	0.86	0.70
6. No. of trips*	38,702	44,130	N/A	40,639
7. Average occupancy per trip	1.74	1.81	1.96	2.73**

Notes:

- all 1980 data provided by Trans-Cab, in personal communications;
- source of data, 1975, 1976 and 1977, rows 1, 2, 3, 4, 5 and 7: Stevenson, J., Trans-Cab: An Integration of Transportation Services within Urban Centres. Paper in Proceedings of the North Carolina Taxi and Transit Conference, September, 1978.

* Miller, Gerald K., Taxicab Feeder Service to Bus Transit, Transportation Research Record 650, 1977.

** occupancy now calculated on meter trips.

routes. The establishment of this feeder service was greatly facilitated by the joint ownership of the bus and the taxi company. The method of operation of the system is very similar to the Peterborough example.

A taxicab feeder service has also been established in Bremerton, Washington. In 1976 bus service on low ridership routes was replaced by paratransit service, on a contract basis between the city and a major taxi operator. Considerable cost savings were achieved by withdrawing the bus service to the low density residential areas.

Hail-a-ride Service: A variation on the dial-a-ride service is hail-a-ride. This option has, however, significant potential only in areas and times of relatively high density demand from street hailing. Conventional exclusive ride taxis can also be hailed from the street, the difference between this and hail-a-ride being that the latter is a shared ride trip. Since more than ninety percent of requests for taxi services in suburban areas and in medium and small cities is by telephone, the hail-a-ride potential exists primarily in those high density downtown cores with high volumes of business and/or tourist travel, and at transportation terminals such as airport, railway stations, bus depots and possibly docks.

The adoption of hail-a-ride services is severly hindered in many cities both in Canada and the United States by restrictions on shared riding. Furthermore, some cities prohibit street hailing of vehicles.

Probably the most significant adoption of hail-a-ride services in North America occurred in Washington D.C. in 1974. District taxicabs had long had a very active downtown hail business, but until 1974 the service was exclusive-ride: the first passenger or group of passengers in a taxicab had the right to insist that they be taken directly to their destination before the driver could pick up any additional passengers. In response to the 1974 disruption in gasoline supplies, taxicabs in the D.C. were allowed to pick up additional passengers without first obtaining the consent of passengers already in the cab. This hail-a-ride service has continued to the present time as the standard D.C. taxi service, and appears to be highly satisfactory to both passengers and drivers. It should be noted that the conversion from conventional exclusive-ride to shared-ride services in the D.C. was greatly facilitated by the existence of a zone fare system. Efforts to introduce similar shared ride services in nearby Arlington (Virginia) foundered on the problem of formulating a shared-ride fare structure in the presence of an exclusive-ride fare computed by standard taximeters.

A recent expression of interest in adoption of hail-a-ride taxi services occurred in April 1980 in New York City. Having made special regulatory provisions to permit shared riding in taxicabs during a transit strike, the regulatory authority (the New York Taxi and Limousine Commission) is considering making permanent provision for such services during rush hours. The fare structure for this hail-a-ride service is presenting problems as the cabs currently use taximeters and an appropriate pricing policy for shared ride passengers must be determined which is both equitable for the passengers and easily adoptable by the operators.

As previously mentioned, hail-a-ride services have potential at airports, and depending on applicable regulations, can be relatively easily organized at these sites. Several potential passengers frequently wish to travel to destinations which, though different, lie in the same general direction. To the extent that these passengers can be given the opportunity to travel together, they can obtain lower fares and the taxicab driver can obtain higher revenue; an outcome which is to the advantage of all. Logan Airport in Boston and La Guardia Airport in New York are currently experimenting with schemes to facilitate shared riding from airport terminals to certain destinations in their respective metropolitan areas.

Jitney Service: Jitney service is a paratransit service characterized by operation on fixed or semi-fixed routes with short headways. The service operates on corridors with relatively high demand densities. For the service to be viable the demand must obviously be sufficient to support a fleet of small vehicles operating without schedules on headways of less than about ten minutes. If demand is not sufficient to ensure the economic viability of the jitney service other options such as a dial-a-ride service may be more appropriate.

Jitney services are certainly not a new innovation in the paratransit field. Services were common in many American cities in the 1920's but due to being considered as unfair competition to street car services (many of which were operated by the municipalities) they were almost all legislated out of existence. The streetcar companies were traditionally given monopolistic rights on those routes that were highly profitable and, in return, they had to use some of their profits to provide services on other routes, generally unprofitable but considered necessary. Now that conventional bus services operate at a deficit on all routes, generally speaking, the earlier rationale for outlawing jitney services can no longer be considered applicable.

There are still some jitney services operating in cities in the United States, most notably in Atlantic City and San Francisco and in certain low income areas of Pittsburgh and Chattanooga.

Conventional Transit: A paratransit mode that has received very little attention to date is the utilization of paratransit vehicles to provide service on conventional fixed routes with fixed schedules. This option would appear to be a cost effective approach to providing a transit service in times and areas of low demand density. This scheme has been adopted in some cities in West Germany with the vehicles operating under contract to the public authorities. In a similar manner, North American transit authorities could contract with taxicab companies to operate on specified routes and schedules in lieu of large unprofitable transit buses. The compensation to the paratransit operator could be on the basis of fixed rates per hour, per mile or per passenger, or a combination.

2.2 Shortcomings of Existing/Proposed Vehicles

The vehicles presently in use in paratransit services (passenger cars, special taxi vehicle, standard van, modified van and small bus) are discussed individually below with regard to their shortcomings:

(a) Passenger Car:

Recent downsizing trends have reduced the capacity of the standard sized vehicle to the point where it has limited application in paratransit roles.

The ease of entrance and egress of the passenger car have been reduced by downsizing to the point where these vehicles are unacceptable for transporting the elderly and handicapped.
The passenger car is incapable of transporting a disabled person in a wheelchair, and many models can no longer carry a folded wheelchair in their trunk.

The durability of the vehicle is relatively poor in commercial roles, as it was never designed for a commercial duty cycle. High maintenance costs and low availability normally result after the first year or two of operation.

(b) Special Taxi Vehicle:

(1) Checker:

The only commercial available special taxi vehicle is the Checker, which has the following shortcomings;

- Relatively high capital cost
- Poor fuel economy, due to high weight, and large gasoline fueled engine
- Relatively rough ride in comparison to passenger cars
- Dated body design has little aesthetic appeal to riders
- The vehicle cannot transport a disabled passenger in a wheelchair, due to limited headroom
- On the positive side the vehicle has proven durability, and a spacious passenger compartment.

(2) GSM Taxi:

This vehicle, presently in the later stages of development and marketing, has the following shortcomings;

- Relatively high capital cost
- Unproven durability in its intended role
- Unproven user and operator market acceptance.

The vehicle has, however, overcome most of the disadvantages of the passenger car and checker vehicle and provides a spacious interior, ease of access and egress, wheelchair and ambulatory carrying capacity, and durable body components.

(c) Standard MPV:

This vehicle, namely the van, currently provides paratransit services in a wide range of roles. The van is undergoing downsizing in a manner similar to the passenger car, and present and near term versions of the vehicle have the following disadvantages for paratransit services:

- Difficult entrance and egress, particularly for the elderly and handicapped, caused by its high floor level and limited headroom
- A relatively rough ride in comparison to a passenger car
- Relatively low durability in commercial operation
- Relatively poor fuel economy in urban operations
- Limited interior privacy in comparison to a passenger car

The main advantages of the van are low capital cost and high seating capacity.

(d) Modified MPV:

Modified vans are widely used in paratransit roles, and depending upon the degree of modification, all but the following disadvantages can be eliminated:

- Rough ride in comparison to a passenger car
- Difficult entrance/egress, for elderly and handicapped, due to high floor height
- Low durability in commercial operation
- Poor fuel economy in urban operations

Nevertheless, these vehicles find wide application, as they achieve good seating capacity, with adequate headroom, for minimum capital cost.

(e) Small Bus:

These vehicles are widely used for several paratransit modes, in spite of several disadvantages:

- Relatively high capital cost
- Limited durability, particularly for body on chassis configurations
- Limited interior privacy
- Difficult entrance/egress for the handicapped
- Rough ride in comparison to a passenger car
- Relatively poor fuel economy

In a recent United States project, originally funded by Urban Mass Transportation Administration (UMTA), various firms developed the vehicles described in Section 2.3 of the main report in response to the vehicle requirements indicated in Table 2.2. Subsequently several firms have developed vehicles for paratransit application. Winnebago Industries developed, using internal funds, a family of paratransit vehicles each of which interpreted the requirements of Table 2.2 in a slightly different fashion, and while they were largely in compliance with the elements of the specification, each vehicle is markedly different from the others. As these were purpose-designed vehicles they each represent an improvement over previous vehicles used for paratransit service. The principal disadvantages of the vehicles are their relatively high capital costs, and the fact that they are

TABLE 2.2

VEHICLE REQUIREMENTS FOR UMTA FUNDED PROJECT

Capacity:	Type A - 4 to 6 Regular Passengers + 45.5 kg. Type B - 1 wheelchair + 2 to 4 regular passengers. Type C - 455 kg cargo, no passengers.	
Convertability:	Maximum 2 hours between types A, B and C.	
Floor:	Flat, 30.5 to 35.6 cm above street level.	
Dimensions:	Interior Headroom	147.3 cm
	Height of Door	142.2 cm
	Width of Door	81.2 cm
	Overall Height	190.5 cm
Acceleration:	0 to 67 kph in 10 seconds.	
Fuel Economy:	11.4 km/litre in EPA urban cycle.	
Maintainability:	Minimum downtime for inspection and replacement of power train. Disc brakes on all four wheels	
Access:	Easy and fast entry for all passengers. Suitable for shared ride service. Wheelchair access by ramp.	
Cost Goal:	125% of conventional taxicab.	
Standards:	Meets all applicable Federal Motor Vehicle Standards.	

of unproven durability and are not yet commercially available. The vehicle developed by McFarland Design Inc. has the disadvantage of an all-aluminum body, which poses repairability problems, plus a suspension system/front wheel drivetrain which is loaded beyond its design limits. The vehicle developed by Minicars Inc. is faced with this latter problem plus the fact that it has limited internal room/passenger capacity. One particular Winnebago vehicle, a modification of a Renault van, is relatively unsophisticated in comparison with the others, but may have the best chance of commercial viability due to the simplicity of the modifications, and the production and after market service capability of Winnebago.

In summary, all of the existing commercially available vehicles used in paratransit service possess operational shortcomings as they were not developed specifically for paratransit service. Conversely, those vehicles developed specifically for a paratransit role are not presently commercially available.

2.3 Relationship Between Paratransit Operations and Vehicle Design

The key paratransit operational factors which impact the design of a paratransit vehicle are:

- The number of passengers carried, as this affects vehicle capacity/size.
- The type of passengers (conventional or elderly/handicapped) carried, as this affects interior configuration and means of entrance/egress.
- The duty cycle, as this defines the durability which must be designed into the vehicle, which impacts capital cost.
- The operating mode (demand responsive or fixed route), as this defines the ancilliary equipment requirements, ie. communications equipment.
- Comfort and security of both passengers and driver.
- Operating costs, as impacted by fuel, durability and maintenance.

Whether or not there is an optimum size for a paratransit vehicle is questionable. The 'best' size is very dependant upon the nature of a specific operation. It may not be feasible to design a paratransit vehicle capable of providing the complete range of paratransit services required. A family of vehicles of various sizes, such as that proposed by Winnebago may be more appropriate. A recent study (1) has proposed appropriate sizes for various paratransit vehicles:

Jitney vehicle: 6-12 passengers, with direct access to doors.

Dial-a-ride: 8 passengers, special purpose taxi or van.

Vehicle for handicapped: 4 passengers - 3 in back plus 1 in front.

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(1) Reference 2

The appropriate size of vehicle is often determined by the maximum amount of time that the first (and each succeeding) passenger can be expected to spend in getting to their destination. This includes loading and unloading time which ranges from fractions of a minute per passenger with jitneys to several minutes with handicapped vehicles.

The requirement to carry elderly and handicapped passengers has a profound effect upon the design of paratransit vehicles, particularly in the area of entrance and egress, and internal size and configuration, related, in particular, to wheelchairs. Ramp and/or lift systems are required, along with low floor and entrance step heights, plus flat floors, and wheelchair restraint systems. For a given vehicle, the requirement to carry wheelchairs greatly reduces its total passenger capacity, due to the space required to manoeuver and restrain the wheelchairs. In addition, loading and unloading times become a significant portion of the total trip time. Severe trip routing restrictions are often imposed by the necessity to unload wheelchairs in the same sequence in which they were loaded, due to limited internal manoeuvering room in most paratransit vehicles.

3. LEGISLATION

3.1 Existing Canadian Legislation

The current legislation affecting the provision of taxi and paratransit services is provided by all three levels of Government - Federal, Provincial and Municipal. In general, legislation by Federal and Provincial Governments affects the vehicles whereas Municipal Bylaws affect mainly operating procedures.

3.1.1 Legislation Affecting Vehicles

Canadian motor vehicle legislation contains a clear jurisdictional delineation between vehicles at the point of manufacture/importation and vehicles in use. The former falls under Federal control, and the latter under the provinces(s) in which the vehicle is registered and/or operated.

(a) Federal Legislation

The Federal Motor Vehicle Safety Act, was brought into effect in 1971, and has subsequently been amended from time to time. The Act provides for the enforcement of safety standards for motor vehicles imported into and exported from Canada, or conveyed between provinces. Therefore, the vehicle, at the importer or manufacturer level, prior to sale is required to conform with the appropriate Canadian Motor Vehicle Safety Standards defined in the Consolidated Regulations of Canada, Chapter 1038. Part III of the Act (See Table 3.1) defines which of the present sixty-three individual CMVSS standards are applicable to the thirteen classes of vehicles defined in the Motor Vehicle Safety Regulations.

The classes of vehicles defined in the Motor Vehicle Safety Regulations which are relevant to Paratransit are as follows:

- passenger car
- multipurpose passenger vehicle (MPV)
- chassis - cab
- bus

The legal definition of each class of vehicle is given below along with typical standard commercial vehicles which fall under each classification:

PASSENGER CAR:

> ". . . means a vehicle having a designated seating capacity of ten or less, but does not include an all-terrain vehicle, competition car, multipurpose passenger vehicle, antique reproduction vehicle, motorcycle, truck or trailer."

This definition includes virtually all commercially available passenger cars with less than ten seating positions without four-wheel drive, and not built on a truck chassis. This class of vehicle is subjected to conformance with 41 CMVSS standards out of a total of 63, including stringent occupant protection standards.

TABLE 3.1

CANADA MOTOR VEHICLE SAFETY STANDARDS

		Classes of Vehicles												
EQUIPMENT	CMVSS	Bus	Chassis-cab	Competition Motorcycle	Competition Snowmobile	Minibike	Motorcycles, Motor Driven Cycles & Mopeds	Multipurpose Passenger Vehicle	Passenger Car	Snowmobile	Snowmobile Cutter	Trailer	Trailer Converter Dolly	Truck
Control Location	101	x	x					x	x					x
Shift Sequence	102	x	x					x	x					x
Defrosting Defogging	103	x	x					x	x					x
Wiping and Washing	104	x	x					x	x					x
Hydraulic Brakes	105	x							x					
Brake Hoses	106	x	x				x	x	x			x	x	x
Reflecting Surfaces	107	x	x					x	x					x
Lighting	108	x	x			x	x	x	x			x		x
Headlamps	108.1	x	x					x	x					x
Tires and Rims	110								x					
Rearview Mirrors	111	x					x	x						x
Rearview Mirrors	111.1								x					
Headlamp Concealment	112	x	x				x	x	x					x
Hood Latches	113	x	x					x	x					x
Locking System	114								x					
Vehicle Number	115			x			x		x					
Hydraulic Fluids	116	x	x				x	x	x			x	x	x
Power Windows	118							x	x					
Tire Selection and Rims	120	x	x				x	x				x	x	x
Air Brake Systems	121	x	x									x	x	x
Motorcycle, Motor Driven Cycle & Moped Brake Systems	122						x							
Motorcycle Control and Displays	123						x							
Accelerator Control Systems	124	x	x					x	x					x
Occupant Protection	201								x					
Head Restraints	202								x					
Impact Protection	203								x					
Steering Wheel	204								x					
Glazing Materials	205	x	x				x	x	x			x		x
Door Latches	206		x					x	x					x
Seat Anchorages	207	x	x					x	x					x
Seat Belts	208	x						x	x					x
Belt Assemblies	209	x	x					x	x			x		x

Table 3.1 continued

EQUIPMENT	CMVSS	Classes of Vehicles												
		Bus	Chassis-cab	Competition Motorcycle	Competition Snowmobile	Minibike	Motorcycles, Motor Driven Cycles & Mopeds	Multipurpose Passenger Vehicle	Passenger Car	Snowmobile	Snowmobile Cutter	Trailer	Trailer Converter Dolly	Truck
Belt Anchorages	210	x	x					x	x					x
Nuts, Discs, Hub Caps	211							x	x					
Windshield Mounting	212	x						x	x					
Child Seating and Restraint Systems	213	x						x	x					x
Side Door Strength	214								x					x
Bumpers	215								x					
Roof Intrusion Protection	216								x					
Bus Window Retention, Release and Emergency Exits	217	x												
Rollover Protection	220	x												
Joint Strength	221	x												
Passenger Protection	222	x												
Fuel System	301	x						x	x					x
Flammability	302	x	x					x	x					x
Axle	901											x		
Emission Device	1101	x	x					x	x					x
Crankcase Emission	1102	x	x					x	x					x
Hydrocarbon and CO	1103	x	x					x	x					x
Diesel Opacity	1104	x	x					x						x
Evaporative Emission	1105	x	x					x	x					x
Noise	1106	x				x	x	x	x					x
Lighting	1201									x	x			
Vehicle Number	1202				x					x				
Handgrips	1203				x					x				
Noise	1204									x				
Shielding	1205				x					x				
Engine Controls	1206				x					x				
	1207				x					x	x			
Tie Down	1208											x		
Tow Bar	1209										x			
Brakes	1210									x				
Fuel Tanks	1211									x				

MULTI-PURPOSE PASSENGER VEHICLE:

> ". . . means a vehicle having a designated seating capacity of ten or less that is constructed on a truck chassis or with special features for occasional off-road operation, but does not include an air-cushion vehicle, all-terrain vehicle, golf cart, passenger car or truck."

This definition includes virtually all vans with less than 10 seats, and four-wheel drive vehicles, and such vehicles must meet 32 of the possible 63 CMVSS standards. The relaxation in standards compared to standard cars is in the area of occupant protection, with no requirement in the area of Side Door Strength, CMVSS 214; Bumpers, CMVSS 215; Roof Intrusion, CMVSS 216; Occupant Protection, CMVSS 201; Head Restraints, CMVSS 202; Impact Protection, CMVSS 203; Steering Wheel, CMVSS 204; Hydraulic Brakes, CMVSS 105; Door Locking Systems, CMVSS 114; and Vehicle Identification Number (VIN), CMVSS 115.

CHASSIS-CAB:

> ". . . means a vehicle consisting of a chassis that is capable of being driven, drawn, or self-propelled, upon which may be mounted a cab, and that is designed to receive:
>
> (a) a passenger-carrying or cargo-carrying body including a body that incorporates a prime mover, or
>
> (b) a work performing structure other than a fifth wheel coupling."

This definition includes virtually all of the small bus or van-type vehicles which have a custom made rear passenger or cargo carrying body. As such, the vehicle must meet a total of 25 CMVSS standards, which represent a relaxation from the multipurpose passenger vehicle in the areas of: Nuts, Discs, Hub Caps, CMVSS 211; Windshield Mounting, CMVSS 212; Child Seating and Restraint Systems, CMVSS 213; Fuel System, CMVSS 301; Noise, CMVSS 1106; Rearview Mirrors, CMVSS 111; Power Windows, CMVSS 118; and Seat Belts, CMVSS 208.

BUS:

> ". . . means a vehicle having a designated seating capacity of more than 10, but does not include a trailer."

This definition includes all vehicles with 10 or more seats, including high capacity vans. As such, the vehicle must conform to 35 standards out of a total of 63. In comparison to a passenger car, the bus must meet a reduced number of standards (35 as opposed to 41), with special standards developed specifically for buses in the area of occupant protection.

Since the CMVSS standards tend to be very similar to their U.S. counterparts, the FMVSS standards, vehicles designed for acceptance in the U.S. market normally meet the Canadian requirements.

The standards are enforced via the process of self-certification wherein a manufacturer/importer must certify that his vehicles meet all of the appropriate CMVSS requirements, and provide, upon request, proof of compliance either through test results or engineering analysis. The Road and Motor Vehicle Traffic Safety Branch of Transport Canada is responsible for the enforcement of regulations under the Motor Vehicle Safety Act.

In 1977 an amendment was made to the Motor Vehicle Safety Act allowing exemptions to specific CMVSS standards for specific vehicles, subject to approval of individual applications. The grounds for granting an exemption are as follows:

(i) the creation of financial hardship for the manufacturer or importer applying for the application;

(ii) prevention of the development of new safety features that are equivalent to, or superior to, prescribed safety standards; or

(iii) prevention of the development of new kinds of motor vehicles and motor vehicle systems and components.

Exemptions are not granted if they would substantially degrade the safe performance of the vehicle, if the world production of vehicles by the manufacturer exceeds 10,000, or more than 1,000 of the vehicles are manufactured for or imported into Canada per year. If an exemption is granted, the following limitations apply:

(a) An exemption is granted for two years except in (i) above in which the exemption is granted for a period of three years.

(b) An exemption granted under (ii) or (iii) is limited to 1,000 units of the model exempted.

Thus the CMVSS standards, under the Motor Vehicle Safety Act, regulate the design of vehicles as related to safety considerations.

In 1975, in response to energy shortages, the Federal Government established the joint Government Industry Voluntary Motor Vehicle Fuel Economy Program. The Road and Motor Vehicle Traffic Safety Branch of Transport Canada has responsibility for this program. The original objectives of the program included:

1. publication and distribution of fuel consumption ratings;

2. labelling of fuel consumption information on individual cars and light duty trucks;

3. meeting corporate average fuel consumption values (CAFE), namely:

YEAR	L./100 km.
1980	11.8
1981	10.7
1982	9.8
1983	N/A
1984	N/A
1985	8.6

Legislation has been introduced in Parliament to make compliance with the above fuel economy standards mandatory, and it will likely become effective with the 1983 model year. As it regulates CAFE, it will not necessarily affect the design of individual vehicles, except that the manufacturers will be improving the fuel economy performance of all of their vehicles, in order to comply with the new standards.

(b) Provincial Regulations

All Canadian provinces possess Highway Traffic Acts or equivalent statutes, which regulate licensing of vehicles, traffic on provincial highways and the condition of vehicles in operation. In addition, the Province of Ontario has issued a new regulation on "Vehicles for the Transportation of Physically Disabled Passengers", namely Regulation 167/81, under the Highway Traffic Act, effective September 1, 1981. The Regulation specifies the design or performance of the following vehicle sub-systems:

- passenger access door
- emergency door
- interior finish and accessories
- exterior markings
- loading ramp
- power lift
- wheelchair securement devices
- occupant restraint assemblies
- wheelchair occupant restraint assemblies.

The provincial regulations limit the dimensions and weights of vehicles, by class. Due to the fact that paratransit vehicles are commonly either modifications of or closely resemble existing vehicles, these regulations are not generally restrictive.

3.1.2 Other Legislation

Taxi services in most Canadian cities are regulated by local governments, usually through municipal commissions. Only Quebec has an overall law governing the regulation of taxis in its cities, and in Manitoba the provincial government retains regulatory control over taxis in Winnipeg.

The Economic Council of Canada published a report in 1981 on taxi regulations(1). A discussion of certain points from this report was presented in the Economic Council of Canada's magazine, Au Courant(2). On the subject of taxi operations, the report notes that: although taxi regulations vary enormously across the country, nearly all have the same effect - they create monopoly situations by sharply limiting the number of cabs that may operate in any given area. Most also discourage the use of taxis by more than one passenger per trip (presumably the report intends to refer to one group of passengers as opposed to shared ride), maintain fees at rates that far surpass the actual cost of the service and effectively limit the number of jobs available in the industry and the income of drivers who rent vehicles from taxi owners. The result, according to the Economic Council of Canada report, is high cost and inefficient utilization of taxi services. The report calls for reform of taxi regulations to increase the number of taxis allowed to operate in any given area and for lower taxi fares, which would increase demand for taxi services. The net result would be a more efficient taxi industry and a closer integration of taxi transportation with other forms of urban transit.

Paratransit and taxi being, for purposes of municipal legislation, essentially interchangeable terms, the regulations applying to taxi operations are those that affect the provision of many paratransit operating modes. Despite its high cost, travel by taxi is becoming an indispensible means of transport for a large element of the population requiring transportation operating with flexible schedules and routes. Taxis are for many people - particularly the elderly, the handicapped and the disadvantaged - a necessary substitute for the private automobile and a much needed complement to urban mass transit systems.

A number of bylaws that control taxi (and thus paratransit) operation have been reviewed. As noted in the Economic Council of Canada report, these regulations vary enormously. Generally speaking, most do not seriously hinder the use of vehicles that are currently under development for paratransit purposes. In those cases where some aspect of a bylaw does pose a hinderance it is likely that in the majority of cases the bylaw could be amended. If the vehicle affected can pass the stringent evaluations of the Federal and Provincial governments, except for very particular cases, it would probably be acceptable for use in Canadian cities.

The area of operation that is currently most affected by municipal bylaws is the almost universal prohibition of shared ride operations. Increasing operating costs are causing a re-evaluation of this directive. Most municipalities also require a taxicab to be equipped with a taximeter, which is closely allied with the single fare requirement.

Two examples of particular municipal legislations that may have an impact on introduction of a new vehicle into taxi/paratransit service in specific centres are as follows:

- Ottawa - maximum number of persons to be carried in one trip by a licensed taxicab owner is five;

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(1) Reference 3
(2) Reference 4

  - vehicle must have an encased automobile body having four doors and seating capacity for three or more persons, exclusive of the driver, and is designed with space for storage of luggage.

- Vancouver - the definition of a taxicab is a cab with a seating capacity of not more than seven passengers.

Certain Canadian cities have made differentiations in their municipal bylaws, between conventional taxicabs and vehicles used for the purpose of transporting physically handicapped persons. For example, the Regulations of the Taxicab Board and the Taxicab Act, Province of Manitoba (Cap. 260, R.S.M. 1954), Section 15 state "motor vehicles constructed so that each vehicle has in it a ramp upon which a wheelchair may be pushed up or down with a person seated in such chair and is being used for the transportation of physically handicapped persons, including their accompanying passengers, are exempt from the definition of taxicab and no fees or municipal taxes imposed under this act shall apply to such vehicles". Similarly, in Vancouver, a Class 'L' Handicapped Transportation Cab - a cab that is used exclusively for transporting passengers confined to wheelchairs - has to pay a $50 license fee as opposed to an $80 fee for a taxicab. The Vancouver regulation is more restrictive and less generous than that of the Province of Manitoba but is, nevertheless, a step in the right direction respecting provision of services to handicapped persons.

3.2 Review of Other 'Sample' or 'Model' Legislations

Two sets of legislation have been reviewed in addition to the review of the existing legislation of major Canadian cities.

An example of stringent regulations respecting taxis are the laws applicable in London, England. It is evident from these that the introduction of any vehicle, other than those currently utilized, would be most difficult.

In London the Assistant Commissioner of Police has responsibility for regulating the physical characteristics of vehicles and the qualifications of drivers.

3.3 Implications of Legislation on Vehicle Technology and Design

Generally speaking, municipal regulations are the area that determine whether or not a newly developed vehicle will be admitted into service. The Federal and Provincial regulations that govern the design and safety parameters of the vehicle must already have been complied with prior to attempting to introduce the vehicle to the marketplace. These latter regulations can be considered inflexible in that they have been progressively developed over years and radical changes, or exceptions permitted to the regulations, are highly unlikely. The regard with which these regulations are viewed is demonstrated in the fact that insurance companies will insure vehicles that meet these requirements, without imposing additional insurability regulations.

Municipal regulations can prohibit a newly developed vehicle that has met all Federal and Provincial regulations from being used in a taxi or paratransit role. These regulations are not inflexible. Bylaws can be changed and, in many cases, the reason for their current wording is because they have never been questioned, despite possible radical changes in both operating modes and vehicle technology since the bylaw was written. In cases where bylaws may not permit the use of a certain type of vehicle it may be possible to provide a special permit for use of that vehicle. This has in fact recently been done in a major Canadian city to permit the use of the GSM taxi.

The current Federal and Provincial regulations regarding vehicle specifications are well justified and require no change. Vehicle producers must abide by these regulations. Some municipal regulations do impose hardship in introduction of a new vehicle, however these regulations can often be changed and if a new vehicle does offer benefits these changes will be made. Few current municipal bylaws impose any real restrictions on introduction of new vehicles.

4. GUIDELINES AND SPECIFICATIONS

The successful operation of a paratransit service can be greatly enhanced by co-ordination between the areas of vehicle selection and operation. These two areas are in the domain of the provider of the service, however limitations are imposed by the availability of a suitable vehicle, or vehicles, and the regulatory framework within which the operator must work.

This section presents guidelines that address the three principal areas as follows:

- regulations, applicable to the legislators; (Section 4.1)
- operations, applicable to the service provider; (Section 4.2)
- technology, applicable to the developer. (Section 4.3)

Of the above three areas emphasis is given to the guidelines on technology as it has been determined that the provision of paratransit services are generally not unduly hindered by current legislation, and that operating procedures are, to a large degree dependent upon the service demand, density, city size and numerous other variables.

4.1 Guidelines to the Regulator

The degree to which regulations can be, or should be, modified for any reason must take into due consideration the original objective of the regulation. In effect, in the case of a disparity, should the vehicle be modified to fit the regulations or should perhaps the regulations be changed to permit utilization of a new vehicle?

The Government of Canada, through the Federal Motor Vehicle Safety Act, is responsible for vehicle safety. Under certain specific circumstances an exemption may be granted to compliance with Canadian Motor Vehicle Safety Standards. One of the cited grounds for a possible exemption is a situation whereby compliance with the Standards would prevent the development of new kinds of motor vehicles and motor vehicle systems and components. In view of the inclusion of this clause and the basis of the Standards (to ensure safety) it is considered that Federal regulations do not require any modification or reconsideration that would facilitate paratransit operators.

Provincial regulations principally affect areas such as permitted vehicle weights and dimensions and requirements for safety inspections. No areas under provincial jurisdiction have been identified that currently provide a hinderance to the provision of operation of a paratransit service, and thus no modifications are required.

Municipal legislators are those most often determined whether or not an innovative service (such as paratransit), or a new vehicle design, or a combination of the two can operate. It is necessary for municipalities to have control over services such as taxi (and therefore paratransit) operations - this is not disputed - however the implementation of the regulations in place must be realistically undertaken. A particular case in point is where a municipal bylaw (or, in the case of Quebec, the provincial regulation) states that a taxi should have four doors. A regulation of this type was probably initially brought in to prohibit the use of vehicles where access to the rear seat was by means of the door adjacent to the front seat, which folded forward. Strict adherence to this regulation would, however, prohibit the use of a vehicle such as the McFarland Design Paratransit Vehicle, which has only three doors.

The municipal regulations may prohibit or hinder paratransit operations by either adversely affecting use of a new vehicle type, as per the example above, or by influencing the mode of operation to such degree that the paratransit service is not viable in the form envisaged by the operator.

Shared ride travel by taxi is prohibited in most municipalities in North America. This regulation can, in many instances be contrary to public interest in that multiple trips are required where one may have sufficed and been acceptable to the occupants.

Municipal regulations regarding the provision of taxi and/or paratransit services must be reviewed either prior to or upon enquiry respecting provision of a paratransit service. Outdated regulations should not be strictly adhered to without having reaffirmed their applicability. Particular areas of concern are the following:

- legislation respecting permitted vehicle types and/or body styles;
- legislation affecting the number of persons permitted to travel in a vehicle, which is often limited to fewer than the capacity of paratransit vehicles;
- legislation respecting the provision of shared ride services;
- legislation respecting tariffs and fare computation,which is often precisely regulated in association with the regulations concerning shared ride services.

With the continually increasing price of gasoline, the public will, at some stage, start to reduce expenditures on travel. For those who rely, in large part, on taxi or paratransit services the only option is to reduce their frequency of service utilization. The most apparent means by which this reduction in level of utilization can be achieved is by reducing the cost of individual trips by:

- implementation of shared ride services,
- utilization of purpose designed vehicles.

Although some municipalities have made progress in the revision of regulations regarding taxi licensing and regulation, in some instances these changes have been in the right direction but have not gone far enough. For example, the City of Vancouver applies a license fee to a cab that is used exclusively for transporting passengers confined to wheelchair that is $30 less than the fee for a conventional cab. It is suggested that a more appropriate definition for the vehicles to which this reduced rate should be applicable is vehicles that are capable of carrying one or more passengers in a wheelchair.

Apart from the possible contravention of existing municipal bylaws, and thereby the initiation of a regulatory conflict with the municipality, a dispute may be initiated by the provider of an existing transportation service. Historically there have been a number of for hire transportation services that have generally been recognized, either implicitly or explicitly, by appropriate regulating authorities. These have included:

- school bus service
- airport limousine
- ambulance
- contract services
- charter services
- taxicab services
- mass transit.

Paratransit regulatory disputes have been almost variably rooted in the relative definitions of taxicab service and mass transit service and into what niche does paratransit fit. Taxis and mass transit, as the two established poles in the relatively recently identified range of public transportation services, both represent powerful vested interests with immediate concerns over the future direction and control of paratransit. In the context of paratransit services, which reflect a merger between the extremes of conventional transit and taxis, the definitions and applicable regulatory framework tend to be ambiguous and overlapping.

Figure 4.1 indicates the regulatory conflicts that commonly occur between conventionally regulated services and a selection of new paratransit services. A review of these potential conflicts follows.

Medicab. The non-ambulatory, especially those confined to wheelchairs are generally unable to use conventional transit services if certain taxi companies have special lift equipped vehicles, these can be used. If this is the only mode of transportation available it must fulfill a wide range of needs than it does for other citizens. Thus special paratransit services for the non-ambulatory (generally termed 'medicab') have been established in many cities. The service may be provided by a private taxicab operator or by other public, for profit or non-profit organizations. Because of the wide range of needs of a diverse clientele which lack other public transportation options, the service provided may take on characteristics of fixed route service, conventional taxi service, or anything in between. The possibility is therefore open for

FIGURE 4.1

REGULATORY CONFLICTS BETWEEN CONVENTIONALLY REGULATED TRANSPORTATION SERVICES AND NEW PARATRANSIT SERVICES.

New Paratransit Services	Conventionally Regulated Services				
	Limousine	Ambulance	Contract	Taxicab	Transit
Medicab		X		X	X
Shared ride taxi	X			X	X
Dial-a-ride				X	X
Off-peak/feeder services			X	X	X
Human Service Agency providers		X		X	X

conflicts with the conventional public or private operators, possibly involving separate regulatory authorities, such as health departments.

Shared ride taxi. Shared ride taxis often face regulatory resistance from taxi regulatory authorities. This resistance may be supported by certain segments of the taxi industry itself. Shared ride and other innovative concepts may be resisted because of a fear of adverse impacts upon the industry or, possibly, the riding public. To some extend this concern may be justified because, if an appropriate fare structure does not accompany approval for shared ride service, serious problems may arise. Unfortunately uncertainties as to how an equitable fare structure can be assured is often a deterrent to shared ride experimentation. Previous experience with a cumbersome regulatory process that is slow to respond to needed fare structure adjustments is likely to discourage operators from being willing to take a risk with an innovative service the rewards from which are uncertain.

Dial-a-ride. Dial-a-ride services represent a hybrid between two well defined existing services, and may be subject to regulatory conflicts with both, depending upon who may feel threatened by a particular operation. The question of who should regulate the new service is important in that the operating rules will influence how the new service complements or competes with various existing modes. For example, the taxi industry may be interested in seeing the new service controlled under their regulations in order to protect their service from what they perceive as undue competition.

Off-peak/feeder services. Off-peak subsitute and feeder services provided by either conventional taxis or modified vehicles are being tried in many cities in an attempt to augment transit services and make them more cost effective. The intent of these services is to bridge a gap between taxi and transit modes, to the benefit of both. However, the services can take on characteristics of both modes and may be subject to claims of responsibility of transit regulations, taxi ordinances or both. Resolving the problem of establishing a service that by definition is attempting to serve two masters, may delay if not completely prevent successful implementation.

Human service agency providers. Many service agencies receive funding to provide transportation services in addition to social service work. These services have grown significantly in recent years. Since these services are usually provided without charge to the passenger the agencies contend that their service does not fall within any regulatory guidelines. However, as these services expand they create a greater impact upon ridership of conventional modes and this has provided for a basis for court action in some instances in the United States. Ambulance, taxi and transit interests may be involved. In each instance the offended carrier will claim that the agency service is competitive and hence illegal as it is not in conformity with the carrier's own regulations.

The above examples serve to demonstrate the potential of regulatory confusion surrounding the introduction of new paratransit services. Most of the regulations were promulgated at least two decades ago in an era when transportation needs were very different.

A generally less mobile society, coupled with a heavy dependence on the private automobile and a relative lack of social concern for the transportation needs of the poor and the disabled, led to a transportation supply that consisted of a very few, clearly distinguished alternatives. These were generally limited to fixed route transit, exclusive-ride taxi, school bus services, charter services, contract services, and some of the other specific services, such as ambulance and airport limousine.

As the transportation needs of an increasingly mobile society have grown, so have the problems of pollution, congestion, energy consumption, and the awareness of the isolation of the disadvantaged. Increasingly flexible responses are needed, and so conventional modes suffer from inadequacy at the same time that there is a push for new services. Thus, that conventional providers of service are often struggling to protect an increasingly unprofitable existence at the same time that demand for a range of new competitive services is becoming apparent. Their response takes the form of either trying to prevent the new service or trying to assume the right to provide it.

This struggle is complicated by the hybrid nature of most new services. In most cases, at least two different conventional sectors have some basis for an active interest in the new service. This interest may be based on either of two claims:

- The new service shares characteristics of an existing mode which render it subject to regulation by the same authority that controls the existing carrier;
- The new service will be or is sufficiently competitive with the existing mode to cause an adverse impact on ridership and revenue, and should therefore be subject to regulations designed to protect existing carriers.

Carriers affected by a new service have an interest in having that new service regulated, and in particular they are interested in seeing it regulated by their "own" regulatory authority rather than by a different authority.

An existing carrier may even want the right to provide the new service. Prospects for this can be determined by establishment of an appropriate regulatory authority. However the hybrid nature of many new services may continue to generate confusion in an environment where no specific regulations have been designed to respond to the nature of the new service. When responsibility for a new service is assigned to a regulatory authority, that authority frequently attempts to define the new service within the context of conventional services. This has the effect of tying the new service to many of the structures that constrain existing services. If the new service is not actively defined, on the other hand, then confusion will remain as to the basis for regulation of the new service. Thus, for example, a shared ride contract with a human service agency may be argued to be authorized under taxi certification, under contract carrier authorization, or not covered by any regulations at all.

The only way to end this confusion is to define new services in their own right. This must be accompanied by specific rules applicable to the new service as appropriate. Details which must be included for each type of service are: driver and equipment requirements, the method of operation, the basis of fares or charges, and reporting and other general requirements.

In the mid and late 70's the United States government actively promoted wider use of taxicab services and introduction and expansion of paratransit services. A quotation from the Federal Register, October 20, 1976, 41(204), is as applicable to Canadian municipalities now as it was to their Amercian counterparts at that time:

> "Outmoded local laws, regulations and ordinances often constitute a barrier to paratransit implementation. Local and State agencies are encouraged to review existing laws, regulations and ordinances pertaining to paratransit operation and eliminate or revise obsolete requirements or prohibitions that constrain or inhibit the introduction of paratransit services".

4.2 Guidelines to the Operator

The operator of a paratransit service must make a number of important decisions prior to implementation of the service, in order to ensure its viability and efficiency. The principal areas to be covered are:

- assessment of the market
- fleet size and composition
- vehicle selection
- ancillary systems
- vehicle maintenance

4.2.1 The Market

The extent of the potential market and its characteristics must be clearly identified prior to establishment of the operating characteristics of the system. Due in part to the current scarcity of transportation services catering to the mobility disadvantaged the extent of this sector of the population is often not evident. Data may be available from certain social service agencies. For services that are not limited to disabled persons, but rather are capable of carrying both ambulatory and wheelchair passengers, an assessment must be made of the extent of the disabled market in order that the vehicle requirements and vehicle fleet composition may be determined.

Should a potential market be identified that appears sufficiently large to support a new service, the ease of access to the taxi/paratransit industry must be considered. The less the degree of specialization and the greater the degree of competition with existing taxi operators, the greater will be the difficulty in establishing a new service. This will particularly apply to larger metropolitan areas, however it is these centres in which the greatest market potential is to be found. Access to the conventional taxi business is generally both costly and strictly regulated. Establishment of a strictly paratransit service would likely be acceptable to many taxicab operators, however competition with taxis will necessitate adherence to the marketplace rules. It may be that the premium on the vehicle price for a paratransit vehicle, coupled with the expense of market penetration, may be too severe a financial load to be offset by the relatively small increase in potential fare paying passengers obtained by providing a service to the non-ambulatory. The cost of entering the competitive market must be assessed as clearly as the potential for providing a service.

In determining the transportation requirements of the disabled sector of the population their specific trip requirements must be considered. Origin-destination patterns and regularity of trip making may not be consistent with the mobile sector and therefore the use of appropriate factors, in determining the market, is essential.

In entering the market with a paratransit service that offers trips both in competition with existing taxi service in addition to paratransit services for the disabled, on appropriate means may be to associate as affiliate with an existing major operator. This may provide a means of entering the marketplace, for the paratransit operator, while at the same time expanding the services of the taxi operator at little or no financial risk to him. Significant benefits may also be gained through utilization of already established servicing facilities and dispatch and communication networks.

4.2.2 The Fleet

The size and composition of the fleet are important factors. There are advantages in a large scale operation, that is, establishment of a paratransit service with only, for example, fifteen vehicles is less efficient than a service with fifty vehicles. Obviously, the fleet size is dependent upon the demand for the service, however where demand for such a specialized service is less than for a minimum of thirty vehicles the system will face economic hardships. The day of the small taxi operator is fast disappearing and a taxi is a less costly vehicle to purchase than a paratransit vehicle. Again the advantages of association with an existing taxi operation are apparent in fleet size selection as the established conventional taxi operation can be utilized by the paratransit vehicles when not carrying wheelchair passengers.

The paratransit fleet should be as homogeneous as possible to reduce maintenance and parts costs. Where feasible vehicles of different capacities should be obtained from the same manufacturer.

4.2.3 Vehicle Selection

Until recently there were no vehicles specifically made for paratransit service. The major automobile manufacturer contend that the market is of insufficient size, consequently, those vehicle now becoming available are generally produced by specialist manufacturers. The range of available vehicles is not large within any specific capacity range and therefore choice is limited. The vehicle specifications presented in this report may be utilized as an aid in selecting a vehicle, especially in the area of performance characteristics. To a large degree the vehicle selection process is based on individual preference, however, due consideration should be given to features such as vehicle repairability and low operating cost, in order to reduce downtime and increase profits, and increase service reliability. In cases where a paratransit fleet is comprised of vehicles capable of carrying wheelchair passengers as well as conventional vehicles, the selection of those in the latter category should be carefully made. The use of small vehicles should be avoided because, even though they may exhibit lower operating costs, capacity constraints limit their effectiveness for use in the 'shared ride' mode.

4.2.4 Ancillary Systems

Vehicle control and dispatching systems are of extreme importance. An efficient communication system leads to maximization of efficient use of the vehicle. Significant advances have been made in recent years with computer dispatch systems and computer aided systems. These systems offer distinct advantages over conventional radio communication systems, the principal advantage being speed and efficiency. One advantage particularly relevant to provision of paratransit services is the volume of information that can be input into the system for relay to a driver with respect to answering a specific call. Using conventional dispatch methods limits the amount of time the dispatcher can spend in communication with any one driver, to the detriment of provision of a paratransit service where specific instructions may be required.

The initial setting up of a control and communications system is an expensive capital investment at the establishment of a new service, and the cost is fairly fixed regardless of fleet size. Utilization of an existing system by joining with a current operator would avoid the majority of these costs.

Fare computation equipment is generally a necessary addition to the vehicle, especially if duty is both conventional taxi and paratransit oriented. The larger the vehicle capacity, occasioned by provision for wheelchairs, the greater the requirement for high capacity utilization and therefore a system of ride sharing. Deviations from exclusive ride characteristics require modification to the conventional meter fare computation system. Modern electronic meters can be programmed for a varying number of different fare structures. Such meters would appear to be appropriate in vehicles that offer both conventional taxi and paratransit services and, due to their larger than average size, would benefit from shared ride utilization.

4.2.5 Vehicle Maintenance

An effective preventative maintenance program, incorporating specific procedures on a regular interval, should be utilized to prevent malfunctions and breakdowns.

Both preventative and corrective maintenance may be handled in several different ways depending upon the size and nature of the fleet operation:

(a) Contract maintenance out to commercial sources, such as garages, service stations, etc.

(b) Contract maintenance out to other agencies such as city garages, or school bus operators.

(c) Set up an 'in house' maintenance facility.

(d) Carry out basic maintenance work 'in house' and contract out overload work.

If the work is carried out 'in house' the operator should ensure that the facility and equipment are adequate.

A maintenance schedule should be developed including daily checks, monthly checks, and regular checks at predetermined vehicle mileages. The daily check should be carried out prior to the operation of the vehicle, and at the end of the day the driver should file a record of any observed malfunctions/deficiencies.

The regular preventative maintenance procedures and schedules should be followed to avoid reductions in vehicle reliability, longevity, and warranty coverage.

Maintenance records should be kept for each vehicle, and updated after each maintenance action.

A phased program of vehicle replacement should be built into the maintenance program.

4.2.6 Operating Costs

The establishment of a comprehensive maintenance program will go a long way in reducing operating costs. It is important to be able to identify where the operating costs are, in order that reductions in these costs can be attained. For this reason a detailed breakdown by expense item is required. Principal areas of expenditure are identified in the following list:

- driver labour
- driver fringe benefits
- non-driver wages and salaries
- non-driver fringe benefits
- other services (security, maintenance, etc.)
- non-personal services (utilities, advertizing, etc.)
- materials and supplies (fuel, oil, tires, parts)
- insurance and claims
- leases and rentals
- non payroll taxes and fees (licences, business tax, etc.)
- interest
- depreciation (on vehicles, meters, furniture etc.)

The key to keeping operating costs down is to run an efficient operation, and that includes knowing what costs are allocated to what areas and the identification of potential areas for cost reduction.

4.3 Guidelines to the Developer (Vehicle Technology)

In this section, guidelines are given for the vehicle developer, in an attempt to ensure that newly developed vehicles are appropriate for paratransit service.

4.3.1 General Requirements

A paratransit vehicle is intended for use in the commercial transportation of passengers, including the elderly and handicapped (including wheelchairs) through demand-responsive scheduling and/or flexible routing. The optimum passenger-carrying capacity depends largely upon the specific application, but it typically ranges from 4 to 12 seated passengers. Ease of entrance and egress for the general public and the elderly and handicapped should be excellent, in order to minimize loading/unloading time and achieve a high level of service. The vehicle interior should achieve a perception of privacy and security in order to compete with the private automobile. The vehicle should have good performance, and low operating costs in order to be attractive to fleet operators. In addition, the vehicle should carry fleet dispatch communication and/or fare calculation equipment. Guidelines on each of the individual aspects of the vehicle are contained in the following sections.

4.3.2 Vehicle Design/Technology

(a) Configuration

One of the prime requirements of a paratransit vehicle is that of a large flat passenger compartment floor, close to ground level to facilitate the loading of wheelchairs. This is best achieved with a front engine/front wheel drive or rear engine/rear wheel drive configuration. For the capacities required, only two axles are required, and the urban application poses no requirement for four wheel drive. Ease of entrance/egress from sidewalks, on one and two way streets, necessitates passenger doors on both sides of the vehicle in addition to the driver's door. The resulting configuration is a two axle, two wheel drive, front engine/drive or rear engine/drive, with passenger doors on both sides of the vehicle.

(b) Capacity

It is apparent that no single vehicle can fulfill the varied demands and requirements of the paratransit market and consequently, it is proposed that a family of vehicles of varying sizes is required, and the following are suggested as adequate to cover the bulk of the service requirements:

VERSION A - capacity 4 to 6 seated passengers or 1 wheelchair plus 2 passengers

VERSION B - capacity 6 to 8 seated passengers or 2 wheelchairs plus 2 passengers

VERSION C - capacity 10 to 12 seated passengers or 2 wheelchairs plus 6 passengers

(c) Vehicle Frame

A full structural frame should be utilized in order to achieve good collision repairability, and minimize structural damage due to corrosion. The present state-of-the-art is centered around steel frames, but graphite reinforced composite frames may be introduced, and would be acceptable in paratransit vehicles, once the repair technology is commercially available.

(d) Suspension/Steering/Braking

Where feasible, the suspension system should be independent to give an improved ride over urban streets. The suspension system should incorporate springs, and heavy duty shock absorbers. If a kneeling suspension is utilized to achieve low floor height for entrance/egress, it should be designed to permit operation under winter conditions which frequently pack suspension systems with snow and ice.

The steering system should be power assisted in order to reduce driver fatigue in urban traffic conditions. The steering geometry should achieve maximum manoeuvreability (i.e., minimum turning circle) consistent with good handling characteristics at all speeds, and low steering wheel input effort.

The service brake system should utilize drum brakes to ensure good stopping performance with minimum fade. Disc brakes are generally operationally superior to drum brakes, however, they do experience higher maintenance costs and are unjustified in purely urban operations with limited high speed stopping requirements. For maximum stopping performance and minimum driver fatigue, the brake system should be power assisted, either from gasoline engine manifold pressure, or from power steering pump hydraulic pressure.

(e) Power Plant

The prime requirements for a paratransit vehicle engine are:

- adequate performance (torque versus speed)
- good fuel economy
- limited fuel sensitivity
- good convertibility to alternate fuels
- good durability and reliability
- good maintainability
- emissions certification
- low life cycle costs
- good low temperature ignition and driveability

The engine best meeting these requirements, with the exception of fuel convertibility, is the present high speed automotive diesel, in turbocharged form. On the basis of lower first cost and fuel convertability, the present gasoline automobile engine is superior, but will typically consume 30 to 40% more fuel under urban driving conditions. If a gasoline fueled engine is utilized, it should utilize electronic ignition and electronically controlled fuel injection, with either individual cylinder injectors or a throttle-body injector system.

(f) Drive Train

In order to minimize driver fatigue in urban driving, a fully automatic transmission should be utilized, with three or four speeds depending upon the design of a particular vehicle. A transmission with an input torque converter and planetary gearing is recommended, and torque converter lockup in high gear is advantageous in improving fuel economy. The type of drivershaft/differential axle assembly utilized is largely dependent upon whether the vehicle is front or rear axle driven. Drive ratios should be selected to give good gradeability/acceleration performance, without compromising overall fuel economy.

(g) Body

The functional requirements for a paratransit vehicle body include the following:

- low weight for good payload and fuel economy
- good damage resistance - minor collisions
- good repairability - major collisions
- good corrosion resistance.

Based upon repairability considerations, both steel and glass-reinforced fibre bodies are acceptable. Repairability can be greatly enhanced by means of easily replaced body panels, and damage resistance in minor collisions can be improved by a resilient perimeter bumper system, of adequate cross-section, located at the appropriate height. The body should incorporate wide passenger doors on both the curbside and roadside in addition to the driver's door. Easy access should be provided to both the luggage area and also to the engine for maintenance purposes. In order to permit the loading of wheelchairs, the curbside passenger door should be fitted with a ramp system, either manually or automatically deployed. This ramp, when deployed, should have a slope no greater than 12:1 when the vehicle is adjacent to a 12.7 cm curb. The ramp should have a width of at least 0.69 m, with raised edges, and should be covered with an anti-skid surface. The door width should be no less than 0.91 m, and preferably 1.0 m, with minimum height of 1.35 m, and preferably 1.44 m.

(h) Interior

The passenger compartment of the vehicle should have interior headroom of 1.47 m, and should have a flat floor area for wheelchairs, with a floor height of 0.3 m above street level. The passenger area should be fitted with adequate fixed and folding seats to meet the seated and combination seated/wheelchair capacity requirements. Side and rear windows should be provided to yield a good view of the vehicle surroundings.

The driver's compartment should contain a vertically and horizontally adjustable commercial quality seat for the driver, meeting the following requirements:

- proper ergonomic relationship with all controls and instruments

- positioned so as to perceive and respond to all components of the driving task

- ease of entry and egress

- ease of observation and communication with passengers

- minimization of fatigue

- easy access to dispatch/communication and fare computation equipment.

The driver's console should contain all instruments necessary to monitor the engine and auxiliary systems in addition to the controls necessary for the operation of the vehicle.

For reasons of privacy and security, a transparent bullet-resistant screen should be fitted between the driver and passenger compartments. The screen should permit easy communication plus the passage of currency, tickets, or tokens to pay for the fare.

Adequate storage space for luggage should be provided within the vehicle interior, either in a trunk, or adjacent to the driver's position. A roof rack should be provided for occasional excess baggage.

Interior paneling and liners should be rugged and easily cleaned. Adequate interior lighting should be provided to facilitate entrance and egress under poor ambient lighting conditions.

(i) Climate Control

In a paratransit vehicle, which frequently transports elderly and handicapped passengers, adequate heating, ventilation and air conditioning (HVAC) capacity is essential. Vents and HVAC outlets should be placed to avoid drafts directly on the passengers. Adequate air flow is important, particularly in the case of respiratory problems. Due to the different HVAC demands within the driver and passenger compartments, a separate air delivery system should be utilized for each compartment.

(j) Restraint Systems

For designated seating positions, passenger restraint sytems complying with the appropriate CMVSS regulations should be fitted. Wheelchair restraint systems should be supplied that are in compliance with Ontario O.R. 167/81, (Vehicles for the Transportation of Physically Disabled Passengers) or other appropriate provincial or municipal regulations.

4.3.3 Vehicle Performance

(a) Acceleration

The paratransit vehicle should be designed so as to produce an acceleration time to 65 km/h, at curb weight, of 8 to 11 seconds, in order to possess adequate gradeability and facilitate passing and merging in congested urban areas.

(b) Fuel Economy

The paratransit vehicle should achieve a fuel consumption rate of 11.2 to 14.1 litres per 100 km when operated on the EPA urban driving cycle.

(c) Braking

The paratransit vehicle should achieve a maximum stopping distance of 60.6 m from a speed of 100 km/h, with minimal fade on repetitive stops.

(d) Handling

The paratransit vehicles should have the following curb-to-curb turning circles:

	Desirable	Acceptable
VERSION A	12.13 m	14.3 m
VERSION B	16.0 m	18.0 m
VERSION C	20.0 m	22.0 m

Steering effort, both vehicle stationary and at speed should be no greater than a typical passenger car.

Ride comfort should be equivalent to a full size passenger car.

4.3.4 Vehicle Safety

The PTV must comply with all CMVSS regulations in effect for the appropriate classification: passenger vehicle, multipurpose passenger vehicle or bus. Compliance should be achieved by using certified components where possible or by testing prototype and/or production vehicles.

4.3.5 Production

The developer should be aware of the limited demand for paratransit vehicles, and design the vehicle around appropriate materials and processes, without extensive tooling. As of 1982, the estimated U.S. market was 5,000 vehicles per year, and a Canadian market estimate of 500 vehicles per year appears realistic.

4.3.6 Service and Maintenance

In order for the paratransit vehicle to gain wide acceptance, a service infrastructure should be provided. This could be most easily implemented by a cooperative agreement with an existing or specialty vehicle manufacturer network, corresponding to the supplier of major vehicle systems, such as the propulsion system.

The vehicle should be durable and reliable in material and workmanship with a design life of 5 years or 500,000 kilometres and offer maximum protection from corrosion. The vehicle should have the following features to enhance its maintainability:

- easy access to major system components
- maximum utilization of commercially available components
- oil and filter change interval - 10,000 km
- chassis lubrication interval - 40,000 km
- preventative and corrective maintenance to be performed with a minimum requirement for special tools.

4.3.7 Cost

In order to be competive, the paratransit vehicle must have a purchase price comparable to and a life cycle operating cost lower than competitive vehicles. A purchase price premium of more than 50% above competitive vehicles will greatly reduce paratransit vehicle market penetration, in spite of lower life cycle costs.

Due to the high purchase cost of paratransit vehicles, it is essential that their life cycle costs are significantly less than competitive vehicles, or they will not become commercially viable.

4.4 Paratransit Vehicle Specifications

A review of the specifications for currently available vehicles indicates that they all have some shortcomings for extensive use in the paratransit mode. Consequently a set of "model" specifications has been developed for paratransit vehicles. The specifications apply to vehicles of the following three capacities, including both desirable and acceptable levels of design/performance:

Vehicle A - 4 to 6 seated passengers or 1 wheelchair plus 2 passengers

Vehicle B - 6 to 8 seated passengers or 2 wheelchairs plus 2 passengers

Vehicle C - 9 to 12 seated passengers or 2 wheelchairs plus 6 passengers.

Table 4.1 presents the detailed specification of the three vehicles to the desirable and acceptable levels of performance/design.

TABLE 4.1

PARATRANSIT VEHICLE SPECIFICATIONS

Item	Desirable Level	Acceptable Level
General		
Body Type	4 door sedan(1)	
Curb weight (kg)	A = 1410, B = 1690, C = 2030	A = 1590, B = 1860, C = 2230
Weight distribution, F/R	50/50	60/40
Capacity		
Version A	4 to 6 seated, or 1 wheelchair, plus 2 passengers	4 seated or 1 wheelchair, plus 1 passenger
Version B	6 to 8 seated, or 2 wheelchairs, plus 2 passengers	5 seated or 2 wheelchairs, plus 1 passenger
Version C	9 to 12 seated, or 2 wheelchairs, plus 6 passengers	8 seated, or 2 wheelchairs, plus 4 passengers
Vehicle Size		
Wheel base (m)	A = 2.60, B = 3.70, C = 4.60	A = 2.90, B = 3.90, C = 4.80
Track, F/R (m)	1.64/1.64	1.44/1.44
Length (m)	A = 4.25, B = 5.20, C= 6.10	A = 4.60, B = 5.70, C = 6.70
Width (m)	2.02	1.90
Height (m)	2.02	1.90
Ground Clearance (m)	0.20	0.15
Overhang, F/R (m)	0.81/0.81	0.96/1.01
Fuel capacity (range, in km)	425	375
Chassis & Body		
Layout	front engine/front drive or rear engine/rear drive	front engine/rear drive
Body/frame	full frame, steel rails	semi-monocoque
Brake System		
Front	disc	disc
Rear	drum	drum
Power assist.	vacuum or hydraulic	vacuum or hydraulic
Brake swept area (cm^2/kg)	1.4	1.0
Wheels	14" x 5"	13" x 5"
Tires	radial ply	bias ply
Steering type	power assisted	unassisted
Turning circle curb to curb (m)	A = 12.13, B = 16.0, C = 20.0	A = 14.3, B = 18.0, C = 22.0
Front suspension	independent	independent
Rear suspension	independent	non-independent
Engine		
Type	diesel or propane	gasoline
Power (kw/kg)	0.048	0.035
Fuel requirement	diesel or propane(2)	gasoline
Alternate fuels	conversion via retrofit	factory converted
Emission control	to meet CMVSS 1101, 1102, 1103, 1104, 1105	to meet CMVSS 1101, 1102, 1103, 1104, 1105
Availability	3 years experience in the field	new engine

TABLE 4.1 - PARATRANSIT VEHICLE SPECIFICATIONS (continued)

Item	Desirable Level	Acceptable Level
Drivetrain		
Transmission	automatic with torque converter lock-up	Automatic with torque converter, no lock-up
Number of Gear Ratios	3 or 4	2
Instrumentation		
Type	analog or digital	analog or digital
Instruments	speedometer, odometer, fuel level, battery, oil and coolant temp., pressure	speedometer, odometer, fuel level, battery, oil and coolant temp., pressure
Warning Lights	ignition, high beam, door open, parking brake on, oil filter change	ignition, high beam, door open, parking brake on, oil filter change
Accessibility		
Accommodation	easy entry and exit, including wheelchairs - shall be designed to accommodate all individuals between following sizes 95th percentile male to 5th percentile female(3)	easy entry and exit, including wheelchairs - shall be designed to accommodate all individuals between following sizes: 95th percentile male to 5th percentile female(3)
Interior height (m)	1.57	1.50
Seating	easily accessible	easily accessible
Wheelchair ramp		
- angle	12:1 slope, on a 12.7 cm curb	10:1 slope on a 12.7 cm curb
- width	0.90 m with raised sides	0.81 m with raised sides
Handholds	two, adjacent to door	two, adjacent to door
Floor height above ground	0.25 m	0.30 m
Doors		
Width (m)	1.00	0.91
Height (m)	1.44	1.35
Door opening	operates manually with minimum effort	operates manually with minimum effort
Passenger Door location	2 doors each side* (* dependent upon vehicle capacity and configuration)	1 door each side*
Wheelchair Ramp		
Overrunning	ramp edges shall prevent overrunning	ramp edges shall prevent overrunning
Illumination	11 lux over ramp area	11 lux over ramp area
Loading	no permanent deformation	no permanent deformation
Operational mode	manual (or field proven automatic version)	manual or automatic
Wheelchair		
Access	wheelchair entrance and egress with minimum passenger disturbance	wheelchair entrance and egress with minimum passenger disturbance
Orientation	forward facing	angular or rearward
Restraint	meets Ontario O.R. 167/81	meets Ontario O.R. 167/81
Dimensions of Wheelchair	W: to 0.76 m L: to 1.22 m Wt: 250 kg	W: to 0.76 m L: to 1.22 m Wt: 250 kg

TABLE 4.1 - PARATRANSIT VEHICLE SPECIFICATIONS (continued)

Item	Desirable Level	Acceptable Level
Folding and jump seats	manually locked in stowed or deployed position	manually locked in stowed or deployed position
Driver Station		
Anthropometric Accommodation	5th percentile female to 95th percentile male(3)	5th percentile female to 95th percentile male(3)
Fare meter (if applicable)	visible to driver and passengers	visible to driver and passengers
Communications	two-way radio for driver	two-way radio for driver
Driver protection	optional bullet resistant partition between driver and passengers	no partition
Restraint Systems		
Driver	3 point, lap and shoulder (subject to provincial discretion)	complies with CMVSS 208, 209 & 210
Right front passenger	3 point lap and shoulder	"
Rear seat passengers	2 point, lap belt	"
Climate Control		
H/V and A/C	front and rear HVAC	HV only, front and rear
Defrosting	all windows	front and rear windows
Maintenance and Repair	heavy duty components to minimize life cycle costs	heavy duty components to minimize life cycle costs
Service intervals:		
Oil & filter change	10,000 km	8,000 km
Chassis lube	40,000 km	30,000 km
Body components	minimum damage from moderate collisions	moderate damage
Structural configuration	maximum interchangeability of body parts, and easy replacement	limited interchangeability
Service access	easy for engine, drivetrain and suspension	is accessible
Interior	high durability easy to clean easy replacement	high durability easy to clean
Vehicle service	utilize diagnostic equipment for base vehicle	no diagnostic equipment
Federal Standards	shall comply with CMVSS passenger car standards in effect	shall comply with CMVSS
PERFORMANCE SPECIFICATIONS		
Acceleration		
0-65 km/h at curb wt	less than 8 seconds	less than 11 seconds
Fuel Consumption		
EPA Urban	better than 11.2 L/100 km	better than 14.1 L/100 km

TABLE 4.1 - PARATRANSIT VEHICLE SPECIFICATIONS (continued)

Item	Desirable Level	Acceptable Level
Handling		
Lateral acceleration 30.3 m radius	0.6 G	0.4 G
Braking		
Minimum stopping distance from 100 km/h	60.6 m	60.6 m
Pedal effort for 0.5G stop	154 N	500 N
Fade: percent increase in pedal effort to maintain 0.5 G deceleration in 6 stops from 100 km/h	20%	20%
Interior Noise		
Idle in neutral	61 dBA	65 dBA
Full throttle acceleration	90 dBA	95 dBA
Constant 50 km/h	65 dBA	70 dBA

FOOTNOTES

(1) Four doors may not be always necessary, depending on vehicle design, providing adequate access for driver and passengers is provided.

(2) Natural gas is an additional alternative fuel option, however the current state-of-the-art for this fuel is not as advanced as for diesel or even propane.

(3) The terminology "95th percentile male to 5th percentile female" refers to that group of persons falling within those boundaries, that is, excluding the 5% largest males and the 5% smallest females.

4.5 Conclusions

The demand for mobility for transportation disadvantaged persons, and hence for paratransit services, is on the increase. The funds available to transit authorities and service groups to provide this service are often not readily available. For the maximum increase in supply to be achieved, all available resources must be utilized efficiently. The three principal areas that can impact the provision, or hinderance, of a paratransit service are legislation, mode of operation and vehicle availability and selection.

Legislation at the regional or municipal level generally has the greatest potential impact on service provision and vehicle use. Federal and provincial legislation is related primarily to vehicle safety and conformity with sizes and weights. Many municipalities have ordinances or bylaws that should be reviewed and updated to ensure that prohibition of a particular type of paratransit service is not unintentionally included.

The efficiency of service operation is key, especially in times where operating costs are rapidly escalating. A market assessment and system design must be undertaken prior to establishment of a paratransit service. An efficient operation demands knowledge of all areas of expenditure, and consequently identification of those costs that can be reduced to improve service profitability.

Principally due to their low initial cost, standard passenger cars, vans, and modified vans find extensive application in paratransit service. These vehicles, not being designed for the continuous duty cycle of transit applications, frequently suffer from increased maintenance or reduced longevity, resulting in appreciably increased operating costs. The dimensions of converted vehicles, and the ease of access and egress, are commonly unsuited to passengers who are either in wheelchairs or are otherwise mobility disadvantaged.

There is a role for an unique purpose-designed paratransit vehicle, or family of vehicles. Until recently little attention has been paid to the design of these vehicles, due principally to the limited market (estimated at 5,000 to 10,000 vehicles per year in North America). This market volume is too small to interest the major manufacturers and too large to be covered by the small custom manufacturer. The continued downsizing trends in the family passenger car and van market may well limit the usefulness of these vehicles in paratransit operations, thereby giving rise to a new purpose-built paratransit vehicle. In order to permit such a vehicle to appear in the marketplace, great attention should be paid to the vehicle specifications and vehicle operating costs, longevity and other such factors.

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